User's Manual

SIMPROCESS

Release 4

CACI

EVER VIGILANT

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Organization of the SIMPROCESS Documentation Set

The SIMPROCESS documentation set consists of three manuals:

- *Getting Started With SIMPROCESS*
- *SIMPROCESS User's Manual*
- *SIMPROCESS Metadata Manual*

Getting Started

The *Getting Started With SIMPROCESS* manual is a must for first time SIMPROCESS users. This manual can also be used for evaluation purposes. Chapter 1 provides an overview of Process Modeling and Analysis and the SIMPROCESS product. Chapter 2 provides system requirements and installation instructions. Chapters 3 and 4 of the *Getting Started With SIMPROCESS* manual provide a tutorial, and Chapter 5 provides a description of the demonstration and reference models.

User's Manual

The *User's Manual* can be opened directly from the **Help/SIMPROCESS Manuals** menu. It is

divided into three parts. Part A is an excellent reference for beginners and casual users. This part contains detailed documentation of the basic and intermediate functions of SIMPROCESS. Chapters 1 and 2 provide SIMPROCESS terminology and basics. Chapter 3 provides a detailed description of SIMPROCESS Statistical Constructs and their use. Chapter 4 describes in detail how the SIMPROCESS Activity Modeling blocks are used. Chapter 5 describes the use of Resources. Graphical Modeling Constructs are covered in Chapter 6. Chapter 7 is dedicated to Activity-based Costing, and Chapter 8 covers the Output Reports for analysis.

Part B is a reference intended for advanced users of SIMPROCESS. This part contains detailed documentation of the programming and library management functions in SIMPROCESS Professional Edition. Chapter 9 documents Reusable Templates and Library Management. Chapter 10 covers the Advanced SIMPROCESS constructs such as attributes, expressions, and time stamps. Chapter 11 wraps-up the advanced features of SIMPROCESS with descriptions of the complex features of the Generate activity and Downtime Schedules for Resources.

Part C describes the integrated statistical tools included with SIMPROCESS Professional. Chapter 12 of this manual provides an introduction to data analysis and ExpertFit. Chapter 13 covers using the SIMPROCESS Database, while Chapter 14 discusses using the Experiment Manager. How to do optimization using OptQuest is in Chapter 15, and Chapter 16 discusses SIMPROCESS Dashboards.

Metadata Manual

The Metadata Manual describes how to build and edit SIMPROCESS metamodels, assign metamodels to a SIMPROCESS model, and enter metadata in a SIMPROCESS model.

Part A
SIMPROCESS Functions and Features

The chapters in Part A describe the basic functions and features of SIMPROCESS.

CHAPTER 1

Process Modeling and Analysis with SIMPROCESS

The goal of Process Modeling is to create a simplified but useful model of a business enterprise. The enterprise can be a small work group or development team, a particular division, a related set of departments, or even an entire company. The model allows an analyst to study the Processes in a business in order to:

- Determine bottlenecks or wasted effort
- Devise revisions to the Process to correct performance problems
- Select Process designs that give the best results
- Provide cost justification
- Establish performance targets for the new Process implementation.

Many types of tools and techniques are available for Process Modeling. Frequently, a simple diagram or flowchart can expose the obvious redundancies, unnecessary work, and inefficiencies in a given Process. Tools which provide simple diagramming of a Process are called *static modeling tools*. However, to expose less obvious bottlenecks and costs intrinsic to the Process requires information about the resources employed in the Process, measurements of the Processing capacity of the resources, and some measure of the expected workflow through the Process.

Many Process modeling tools today do not allow a quantified analysis of the Process under study. Some of those do not take into account the:

- Time-varying nature of many Processes
- Non-linear interactions among elements of a Process
- Random behavior of most real Processes
- Unexpected events in the business environment

The bottom line is that most Processes are not well characterized by deterministic, mathematical models. A dynamic business Process modeling tool, which can simulate the behavior of the Process as it responds to the events occurring in the business environment, is required to analyze time-varying business processes.

Why Dynamic Modeling?

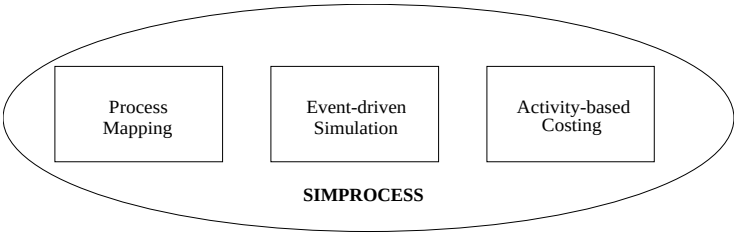
A computerized dynamic model simulates the flow of materials and information through the Process. The dynamic model accounts for the random variations in how work is done and the way materials (and information) flow through the real world. Simulation offers several advantages over a simple pictorial abstraction of a business Process. SIMPROCESS employs discrete event simulation to capture the time-varying nature of the Process under study.

SIMPROCESS advantages include:

- First, the analyst can correlate the data produced by the model with measurements taken from the real Processes to increase certainty that the model has adequately captured the essential features of the real Process.
- Second, the model will generate quantified Process measurements such as: excess capacity or bottlenecks, the time it takes work items to flow through the Process, and the percentage of time expended in value-adding Processes versus non-value-adding Processes.
- Third, the model allows the analyst to evaluate, in quantified terms, the effects of reengineering the Process.

What is SIMPROCESS?

SIMPROCESS is a hierarchical and integrated Process simulation tool that radically improves your productivity for Process modeling and analysis. SIMPROCESS is designed for BPR and IT professionals of industrial and service enterprises who need to reduce the time and risk it takes to service customers, fulfill demand, and develop new products.



SIMPROCESS integrates Process mapping, hierarchical event-driven simulation, and Activity-based costing (ABC) into a single tool. The architecture of SIMPROCESS provides an integrating framework for ABC. The building blocks of SIMPROCESS are Processes, resources, entities (flow objects), activities, ABC, and dynamic Process analysis. ABC embodies the concept that a business is a series of inter-related Processes, and that these Processes consist of Activities that convert inputs to outputs. The modeling approach in SIMPROCESS manifests this concept and builds on it by organizing and analyzing cost information on an Activity basis.

How Do You Use SIMPROCESS?

SIMPROCESS allows you to create an abstract model of a Process under study. You produce a computer model of a business Process and documentation (diagrams and descriptions) to be printed.

SIMPROCESS is a *dynamic modeling tool* that simulates the flow of entities through the defined Process. Entities could be:

- proposals
- orders
- invoices
- customers
- work-in-Process
- patients.

Items, Entities, that a Process receives, acts upon, or produces should be included in the definition of the business Process. Items flow from one Process step to the next and at each step some task is performed. The Resources, such as people, machines, or information required to complete the tasks are also included in the business model.

SIMPROCESS generates valuable information about the Activities, Entities, and Resources in the model. This data is used to validate the Process model. The generated statistics and reports are used to determine where the Process could be improved. SIMPROCESS allows you to evaluate alternatives and different management policies. SIMPROCESS helps a team decide which changes to a business Process will provide the most benefits.

SIMPROCESS Editions

SIMPROCESS has four editions:

- Professional Edition - contains all the features and capabilities of SIMPROCESS. There are no limits on model size for models built with SIMPROCESS Professional Edition.
- University Edition - also contains all the features and capabilities of SIMPROCESS. However, model sizes are limited to no more than 50 Processes and Activities.
- Demonstration Edition - models are limited to no more than 25 processes and activities, 5 entity types, and 5 resource types. Also, none of the advanced features are accessible.
- Runtime Edition - contains all the features and capabilities of SIMPROCESS except the ability to save. There are no limits on model size, but models built or modified in this edition cannot be saved.

SIMPROCESS Terminology and Menus

SIMPROCESS Terminology

This manual uses the following words and definitions in its description of SIMPROCESS.

Activities. An Activity is a basic step in a model where an operation is performed on an entity. Examples of Activities are Generate, Delay, and Dispose. An Activity may or may not involve passage of time or requirements.

Attributes are system and user-defined variables of model elements whose value can change during the course of a simulation run. Attributes may be used to alter the behavior of a Process by changing their value during a simulation. They can also be used to communicate information (such as system time) between two Processes in a model or store data collected during a simulation run.

Connectors link Activities and Processes together and are paths used by entities to flow through the model. Connectors can have delay times.

Cycle time. An Entity's cycle time is the sum of the Processing times and delays it encounters as it is processed in the model.

Entities represents people, goods, or information. Most are produced as a result of a Process or Activity.

Entities are generally created at the Generate Activity, although other Activities (e.g., Batch, Assemble) may produce entity instances as well. Entities must enter a Dispose Activity to ensure statistics collection.

Hierarchical Processes. The concept of a Process provides hierarchical modeling capabilities. A Process is a collection of Activities and sub-Processes organized as a model network.

Layout contains graphical representations of the Activities, Processes, and Connectors that make up a SIMPROCESS model. The Entities only appear on the layout while the simulation is running. The layout can be made to resemble the physical layout of a system, or it can be closer in appearance to a flow diagram.

Model is a representation of the system being studied. It is not intended to be an exact duplicate of the system, but rather a simplified version that captures the relevant features.

Pads are small triangular graphic objects located along the border of an Activity or Process. Pads are used for attaching connectors to the inputs and outputs of the Activity/Process. Entities enter and exit Activities through input and output pads.

Alternative Process/Sub-Process. Alternative Processes define alternative behaviors or flows of a

Process. Multiple alternatives can be associated with a Process, but only one can be active at a time.

Resources are the agents required to perform an Activity. People, computers, and trucks are all examples of Resources. Resources may be consumable (e.g., oil or paper) or reusable (e.g., trucks).

Simulation is defined as the reproduction of the dynamic and random behavior of a business Process with the goal of quantifying some key characteristics of the business Process.

Templates of Activities, Processes, and Resources can be stored in a Library for reuse.

SIMPROCESS Menus

File Menu

New creates a new model file.

Open loads a previously saved model. If the model directory (see **Save As...** below) does not exist, it is created during the **Open** process.

Open Recent contains a list of recently opened models. The first item is **Clear Menu**, which removes all recently opened models from the **Open Recent** menu.

Close closes the active model.

Properties opens a dialog that tracks the edit history of a model.

Group ID controls the **Group ID** of a model. There are two submenu items:

- **Assign Group ID**
- **Clear Group ID**

Assign Group ID will be enabled if no **Group ID** is assigned to the model; if one is assigned, **Clear Group ID** will be enabled. No dialog is displayed by either action. If used, the **Group ID** is created internally by SIMPROCESS. Assigning a **Group ID** facilitates collaborative work on a model using a master model and templates placed into a Library. (See "Reusable Templates and Libraries," beginning on page 223 for more information on templates and Libraries.)

When a model is saved, SIMPROCESS assigns it an internal model ID. Each time a Process or Activity is added from a template in a Library, the model ID is checked against one stored with the template to determine whether the template was originally created from that same model. If it was, the creation of Attributes, Resources, Entities and other items is suppressed based on the presumption that they will already be present in the model. Each time a copy of a model is saved using the **Save As** command, the internal model ID is changed. Saving a copy of the model to another name to give to team members involved in collaborative model development is therefore not ideal. Any templates they might create from the copy would not share the model ID of the original. This results in duplication of Attributes, Resources, Entities and other items into the master model when the team member's efforts are merged back into it via Library templates. The **Group ID** identifies models created with **Save As** as belonging to the master model (using **Assign Group ID** on an open model causes that model to become a master model). **Save As** does not change the **Group ID**. Thus, if the master model has a **Group ID** assigned, every copy of the master model made via **Save As** will carry the same **Group ID**. When a template is placed into a Library from any Process or Activity, the **Group ID** will be stored in the template along with the model ID. When a template is added to a model, the **Group ID** is checked before the model ID to avoid duplication of Attributes and other items. Only if no **Group ID** is present in the model or if the **Group ID** of the model and the **Group ID** of the template do not match will the model ID check be performed.

Save saves the model. Saving a model that has not previously been saved will execute **Save As...** so the model can be named.

NOTE: It is a good idea to save a model any time you make changes to it and to save a model under a different name any time you extensively change a model. SIMPROCESS saves your models with the extension `.spm` and at the same time also saves a backup with the extension `.bck`. To save a new model or to save an existing model under a new name, use **File/Save As...**. For information on automatic saving, see "Other Preferences" on page 33.

Save As... is used to save a model for the first time, or to save a model with a new name. **Save As...** creates a directory for the model (referred to as the model directory) that has the model name without extension and is in the same directory as the model file. The model directory is the default location for input and output files of various types and is the preferred location for imported images (see "Importing Graphics Image Files," beginning on page 168) and external Java classes (see "SIMPROCESS and External Java Classes," beginning on page 602). Note that when performing **Save As...** the complete contents of the previous model directory are copied to the new model directory.

Import

Version 2.2.1 Model... imports a SIMPROCESS version 2.2.1 or 2.2.2 model. Due to changes in the graphical coordinate system from earlier versions of SIMPROCESS to the current version, some cleanup will be required. See "Importing Version 2.2.1 Models," beginning on page 452 for more information.

XPDL Model... imports an XPDL model. (See http://www.wfmc.org/standards/docs.htm for information on XPDL.) At a minimum, the following must be true of the XPDL model for the import to SIMPROCESS to be successful.

- The XPDL model must validate against the XPDL 1.0 schema at http://www.wfmc.org/standards/docs/TC-1025_schema_10_xpdl.xsd, or the XPDL 2.0 schema at http://www.wfmc.org/standards/docs/TC-1025_bpmnxpdl_24.xsd.
- There must be at least one `WorkflowProcess` element with the `AccessLevel` attribute set to **PUBLIC**.

Not all elements of an XPDL model are imported to SIMPROCESS. The following table shows the XPDL elements that are imported and their corresponding SIMPROCESS constructs.

XPDL Element	SIMPROCESS Construct
WorkflowProcess	Process
ActivitySet	Process
Activity	Activity
Transition	Connector
DataField	Global Entity Attribute
FormalParameter	Global Entity Attribute
Performer	Resource
TypeDeclaration	Entity Type
SimulationInformation/ TimeEstimation/Duration	Activity Delay Time

If x-y coordinates for Activity elements are to be imported, they must be in an `ExtendedAttribute` element with the attribute `Name` set to **Coordinates**. The child element containing the x and y values must have the attributes `xpos` and `ypos`. The name of the child element does not matter. Below is an example of an XPDL Activity that includes coordinates.

```
- <Activity Id="9">
   <Route />
 - <TransitionRestrictions>
```

```
  - <TransitionRestriction>
   - <Split Type="AND">
    - <TransitionRefs>
       <TransitionRef Id="1" />
       <TransitionRef Id="38" />
       <TransitionRef Id="2" />
      </TransitionRefs>
     </Split>
    </TransitionRestriction>
   </TransitionRestrictions>
-  <ExtendedAttributes>
-   <ExtendedAttribute Name="Coordinates">
     <xyz:Coordinates xpos="572" ypos="389" />
    </ExtendedAttribute>
   </ExtendedAttributes>
  </Activity>
```

The type of SIMPROCESS activity that is created is based primarily on whether or not a `Route` element exists as a child of the `Activity` element. If there is no `Route` element, then the corresponding SIMPROCESS activity is a Delay activity. If there is no `Route` element and there is an `Implementation/SubFlow` element, the corresponding SIMPROCESS Activity is a Process. Other factors concerning `TransitionRestrictions` come into play when determining other types of SIMPROCESS Activities. As an example, the `Activity` element above would result in a Split Activity in SIMPROCESS. This is because there is a `Split` element within a `TransitionRestriction` element, and there is more than one `TransitionRef` element.

Note that if the XPDL model being imported was previously exported from SIMPROCESS 4.3 or higher, the model may contain some SIMPROCESS unique information that will help appearance. During import, if SIMPROCESS detects unique information from other applications, this information will be transferred to the new SIMPROCESS model. Thus, if the SIMPROCESS model is later exported to XPDL, that application unique information will be exported as well.

Background... imports a Graphics Interchange Format (GIF), Joint Photographic Experts Group (JPEG or JPG), or Portable Network Graphics (PNG) file for use as a background image.

Export

Graphics Image File... creates a JPEG image of the current layout.

Simulation Results... exports the results of the current model to a tab-delimited file. The data from all reports selected for the current model will be written to this file. The file can be opened with a text editor or spreadsheet.

Activity List... outputs the Process and Activity hierarchy to an ASCII file.

UML Activity Model outputs the model to a UML-compatible file. This feature is disabled in the SIMPROCESS Runtime version. See "UML Interfaces" on page 592.

XPDL Model outputs the model to an XPDL 2.0 compatible file that follows the schema at http://www.wfmc.org/standards/docs/TC-1025_bpmnxpdl_24.xsd. (See http://www.wfmc.org/standards/docs.htm for information on XPDL.) Exported XPDL models will contain some SIMPROCESS unique information. This information is only useful to SIMPROCESS and should be ignored by other applications importing the model. The table below shows how SIMPROCESS model constructs export to XPDL.

SIMPROCESS Construct	XPDL Element
Process	WorkflowProcess
Activity	Activity
Entity	TypeDeclaration
Resource	Performer
Attribute	DataField
Connector	Transition
Branch Connector	Transition/Condition
Activity Delay Times	SimulationInformation/ TimeEstimation/Duration
Swimlanes	Pools/Pool/Lanes

Ultimus creates an XML file compatible with the Ultimus XML Converter. The XML file is created in the model's directory, and the name of the file consists of the name of the model followed by `_Ultimus.xml`. The Ultimus XML Converter uses that XML file to create an Ultimus file (`.wfl`) for use in Ultimus BPM Studio. See www.ultimus.com for more information on Ultimus.

Workpoint creates an XML file that can be used to create a WorkPoint archive file. The WorkPoint archive file can be imported into WorkPoint to produce a WorkPoint process. The XML file is created in the model's directory, and the name of the file consists of the name of the model followed by `_WorkPoint.xml`. Note that a WorkPoint process created from a SIMPROCESS model contains minimal information and is merely intended to provide a starting point from which to begin implementing an actual WorkPoint work flow. The table below shows the mapping of SIMPROCESS Activities to WorkPoint objects.

SIMPROCESS	WorkPoint
Assemble	Activity
Assign	Activity
Batch	Activity
Branch	Optional Delay
Clone	Not Applicable
Delay	Activity or Delay
Dispose	Stop
Free Resource	Not Applicable
Gate	Delay
Generate	Activity
Get Resource	Not Applicable
Join	Optional Delay
Merge	Not Applicable
Process	Sub-process
Replenish Resource	Not Applicable
Split	Optional Delay
Synchronize	Activity
Transfer	Stop
Transform	Activity
Unbatch	Activity

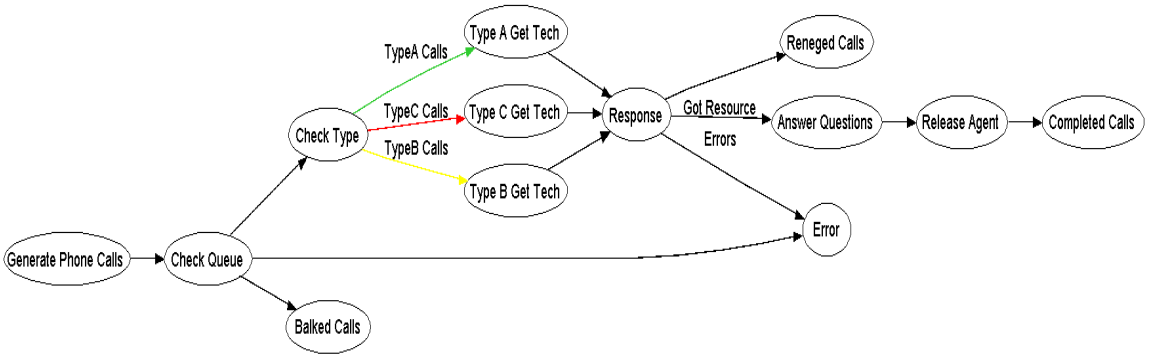
The following table lists the SIMPROCESS data element on the left and the corresponding WorkPoint data element on the right.

SIMPROCESS	WorkPoint
Process Name	Process Name
Activity Name	Activity Name
Activity Comment	Activity Description
Activity Location	Activity Display Info

SIMPROCESS	WorkPoint
Activity Duration	Activity Planned Duration
Delay Duration	Delay Date Offset
Connector Name	Transition Name

- If a SIMPROCESS Connector is a Branch Connector, a dummy Workpoint transition script is generated where the script name is the same as the Connector name and the script description is set to the "Condition" value.
- If a SIMPROCESS Delay Activity specifies Resource usage, a WorkPoint Activity is generated. Otherwise, a WorkPoint Delay node is generated.
- SIMPROCESS Entity definitions can optionally be exported to WorkPoint process user data. The user data name will be the Entity name and the user data value will default to "X".
- SIMPROCESS resources are exported to WorkPoint activity descriptions. If specified, the resources are included in the activity description in the format: "Resource=[resource1],[resource2],...[resourceN]".
- SIMPROCESS does not identify to WorkPoint upstream (or looping) transitions. Therefore, once the model is imported into WorkPoint, the user must locate all upstream transitions and identify them as such by opening the transition properties and setting the appropriate check-box.
- In some cases, the WorkPoint import generates dummy scripts. This means, after the archive file is imported into WorkPoint, the user must edit each of the scripts and set them appropriately.

Dot Workflow creates a workflow file using the Dot language that presents a “flat” (non-hierarchical) view of the model. The file is created in the model’s directory, and the file name consists of the model name followed by `_Dot.txt`. The file can be opened in a graph visualizer such as ZRGViewer (http://zvtm.sourceforge.net/zgrviewer.html). Below is a view from ZRGViewer of the CallCenter demo model.



Publish Model to HTML... outputs the model to HTML format to be made accessible via a standard web browser. Select a destination directory, and a new directory will be created with the same name as the model (with any spaces replaced by underscores).

All layouts will be exported to JPEG image files with web pages built around them. Lists of the model's Activities, Processes, Resources, Entities, and each type of Global Attribute will be provided, including links to the properties of each. The Standard Report data will be included along with any plots that are available via the Display Real-Time Plots menu item, if the model had been executed.

Print

Print Layout... prints a picture of the current model layout, including background icons, but the layout color will not be printed.

Print Model... prints a picture of each screen of the model. The first page is a table of contents.

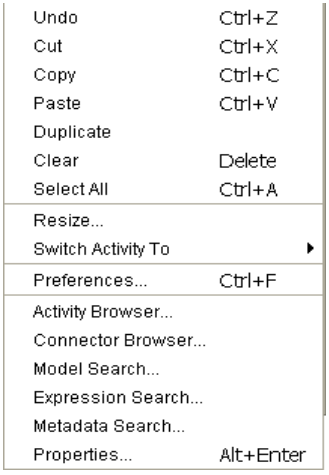
Process Documentation... prints the descriptions of selected Processes.

Model Documentation... prints the description of all elements of the model. This includes **Name**, **Path,** and **Comment** field entries of all Activities/Processes, Connectors, Entities, and Resources in the model. Any information you have added using the **Document** button is also included.

List of Most Recently Used Models. The **File** menu contains a list of the most recently used models. Open any of these models by clicking on its name. The number of recent files is set on the **Edit/Preferences** dialog.

Exit quits SIMPROCESS. If you have made edits since you last saved the open models, you will be prompted to save your models before exiting.

Edit Menu



Undo

Undo restores Activities, Processes, and Connectors that have been cut or cleared (deleted). It also reverses Align and Distribute actions. The **Undo** is only active at the hierarchical level where the **Cut**, **Clear**, **Align**, or **Distribute** occurred. A maximum of 10 **Undo** actions can be active at any one time. As editing events occur that create **Undo** actions, the most recent 10 actions are the ones that are kept. The **Undo** menu and the tool tip for the **Undo** button will update to show the next **Undo** action (**Undo Clear**, **Undo Cut**, **Undo Align**, **Undo Distribute**). **Undo** actions are active in the reverse order of the editing actions that created them. For instance, if Activities are aligned, then an Activity is deleted, the order of **Undo** actions would be **Undo Clear** followed by **Undo Align**.

Cut

Cut cuts the selected object from the model layout. The cut object is copied to the clipboard, and the object may be pasted onto a different part of the layout or into another open model using **Edit/Paste**. Connectors and Pads cannot be cut. They can only be cleared.

Copy

Copy places a copy of the selected object in the clipboard. It will remain there until replaced by another object that is cut or copied. Once a copy is made, it can be pasted on the layout or into another model by using the **Edit/Paste** command.

Paste

Paste makes a copy of the object in the clipboard and pastes it onto the layout. Multiple copies of an object can be pasted without additional copies being made. Pasting items into a model different from the model where the copy or cut occurred can cause loss of entity, attribute, resource, function, or distribution references. See "Advantage of Templates Over Copy/Paste" on page 236 for more information.

Duplicate...

Duplicate... is a shortcut that copies a selected object from the layout and then does a paste to a position selected on the layout. This combines **Copy** and **Paste** into one command. This is useful when you want to quickly copy something on the layout and paste it somewhere else.

Clear

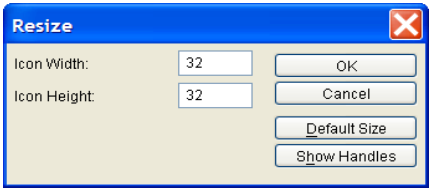
Clear deletes a selected object without copying it to the clipboard.

Select All

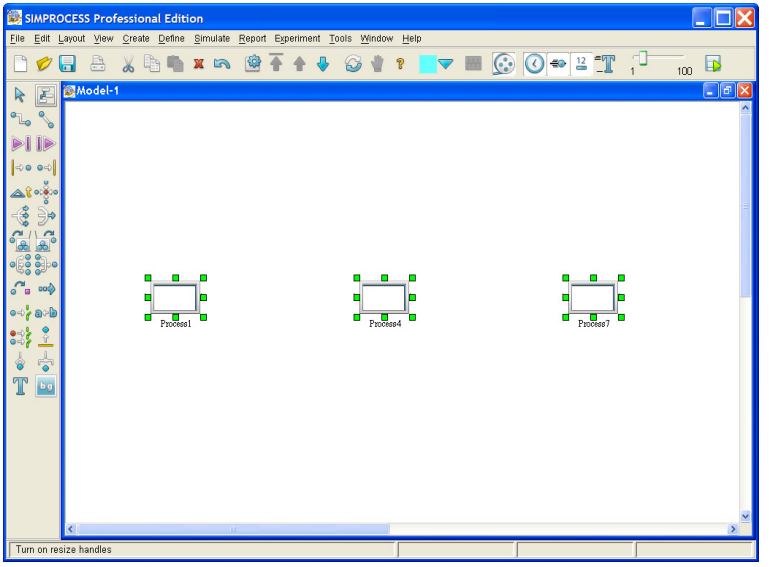
Select All selects all objects on the model layout.

Resize

Resize lets you resize a layout object. You can resize the horizontal and vertical directions separately if you wish to resize the icon in a non-proportional way. The values represent pixels. The **Default Size** button sets the **Icon Width** and **Icon Height** to the default size of the icon. Choose the **Show Handles** button if you would like to drag to resize the object. Multiple objects can be resized at the same time by having multiple items selected when choosing **Resize**. **Important Note**: An object cannot be resized smaller than 10 x 10 pixels. Thus, if numbers are entered that are smaller, the object will be resized to 10 x 10. Also, Background Text objects cannot be resized using **Resize**. The font properties must be changed to resize Background Text.



The following image shows three processes after **Show Handles** was selected.

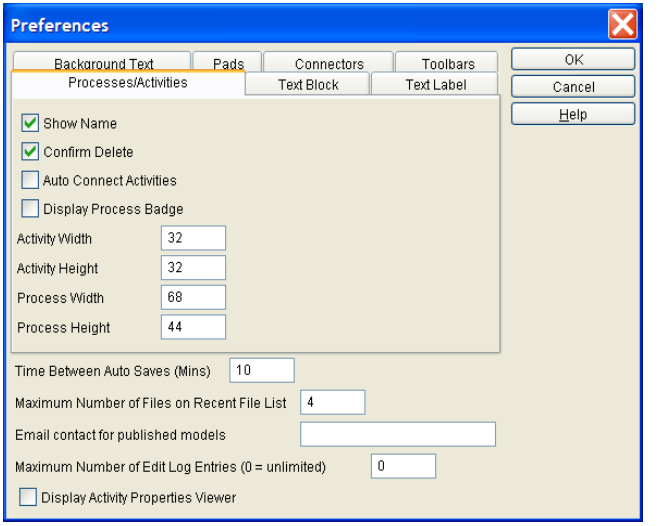


Switch Activity To

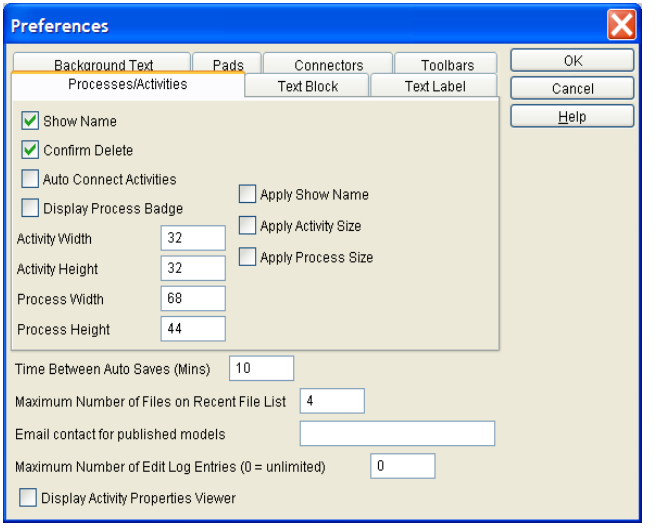
Switch Activity To changes an activity from one type to another. This menu item is only displayed when one and only one activity is selected on the layout. Processes do not activate this menu item. Items that are in common between the old activity type and the new activity type are transferred to the new activity. Since some activities allow multiple connections to output pads and some do not, all connections to the old activity may not transfer to the new activity. This menu item also displays on the pop up menu.

Preferences

Preferences allows the setting of personal preferences for various options in SIMPROCESS. These preferences take effect after the dialog is closed.



If a model is open when the **Preferences** menu item is selected, check boxes appear that allow selection of preferences to be applied to the active model.



Preferences selected for application to the active model are applied when **OK** is clicked. Before the selected actions are applied to the active model, a dialog confirming that these actions should occur appears.

If **No** is selected, the active model is not updated. It may take a few minutes to apply updates to a large model. Other editing actions are not allowed while the update occurs. Note that these updates actually change the properties of the active model. The options to display or not display Activity, Pad, and Connector names on the **View** menu do not change the model properties, just what is currently visible. (See page 51.)

There are seven tabs on the Preferences menu:

- Processes/Activities
- Text Block
- Text Label
- Background Text
- Pads
- Connectors
- Toolbars

Processes/Activities

Show Name specifies to show the name on the layout by default for newly created Activities.

Confirm Delete causes a confirmation dialog to appear when you delete an Activity or a Process.

Auto Connect Activities causes new activities placed on the layout to automatically connect (if possible) with any previously selected activities. The type of connector to use (**Bent** or **Straight**) is set on the **Connections** tab. This option can also be turned on/off on the pop up menu.

Display Process Badge causes a small icon (green plus sign) to display on the lower right hand corner of non-empty Processess.

Activity Width/Height sets the default width and height of new Activities.

Process Width/Height sets the default width and height of new Processes.

Text Block

Show Text Block displays the text blocks for the Activities on the layout.

The **Font Attributes** set the default **Font Name**, **Size**, **Color**, **Bold** and **Italic**.

Text Label

The Text Label preferences are for text labels that are created from the Text Block of a Process. See "Labeling with Text Blocks," beginning on page 72 for information on how to use these.

Add Text Label sets whether the label should be added inside the process for each alternative.

Horizontal Text Label sets whether the label should be horizontal (selected) or vertical (not selected) on the layout.

The **Font Attributes** set the default **Font Name**, **Size**, **Color**, **Bold** and **Italic**.

Background Text

The **Font Attributes** set the default **Font Name**, **Size**, **Color**, **Bold** and **Italic**.

Pads

Show Name shows the pad names on the layout.

Confirm Delete causes a confirmation dialog to appear when you delete a Pad.

Pad Size specifies the default size of pads: **Small**, **Medium**, or **Large.**

Connections

Show Name displays Connector names on the layout.

Confirm Delete causes a confirmation dialog to appear when you delete a Connector.

Line Width specifies the default line width for new Connectors.

Line Style specifies the default line style for new Connectors.

Default Connector for Auto Connect specifies the type of connector (**Bent** or **Straight**) to use when **Auto Connect Activities** on the **Processes/Activities** tab is selected.

Toolbars

The display of the System Toolbar and Layout Toolbar is optional.

Other Preferences

Time Between Auto Saves determines the approximate amount of time between automatic saves of the model. The automatic save feature creates a file with the same name as the current model, except with an identifier number assigned by the system added along with the extension `.tmp` (for example, `MyModel41123.tmp`). If the current model is new and has not been saved, the name of the temporary

file will be the model's assigned name (Model-1, Model-2, etc.) along with an identifer number and a `.tmp` extension and will be located in the models directory.

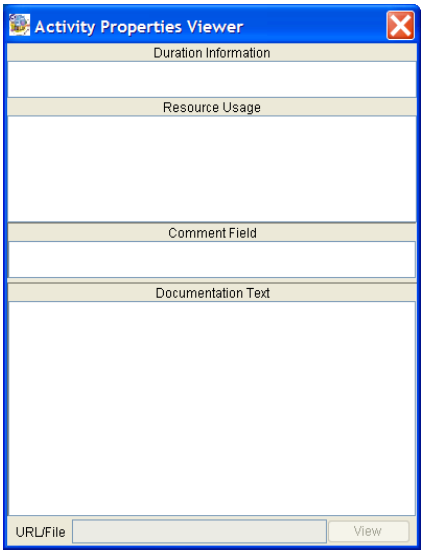
NOTE: The automatic save does not affect the `.bck` file. The `.bck` file is created or updated when you initiate a save. See page 21 for information on the backup file.

Maximum Number of Files on Recent File List defaults to 4. Sets the number of files on the **File** menu. The allowable values are 0 through 9.

Email contact for published models is where the email address is set that is to be used with models published via the **Publish Model to HTML** feature. If an entry is present, the popup menu that appears in published models when holding the mouse over any Process or Activity will include a "mailto" link with this address having a default subject line containing the complete path to the Activity or Process. This is provided so that viewers can offer feedback or ask questions. This email address is not validated. Note that not all email clients will properly handle the use of the "?subject" portion of a mailto link.

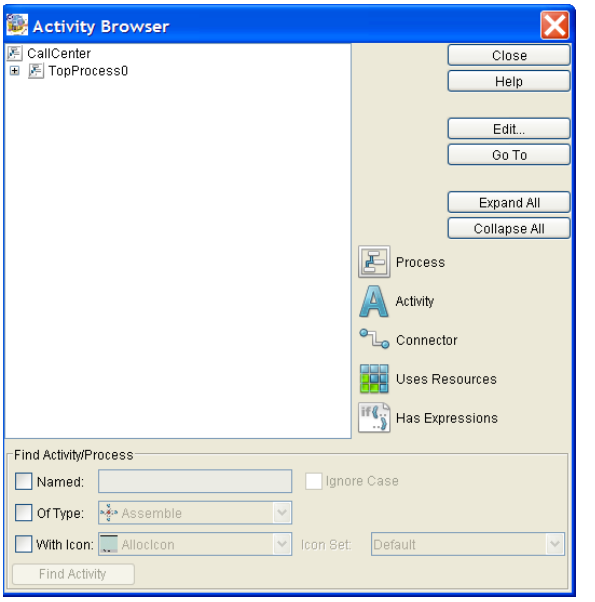
Maximum Number of Edit Log Entries sets the limit of entries in the model's edit log. The default is unlimited (0 entry).

Display Activity Properties Viewer toggles the display of the Activity Properties Viewer dialog. This dialog can be resized and remains visible until deselected here or the dialog is closed. Note that closing the dialog will turn off this setting. Selecting any Activity or Process on the layout will display certain Activity and Process properties. When an Activity is selected, the Activity duration in its **Duration** field displays in the **Duration Information** field, and the Resource usage information displays in the **Resource Usage** field. When an Activity or a Process is selected, the text in its **Comment** field displays in the **Comment Field** section, and the text of the **Documentation** displays in the **Documentation Text** section. The **File/URL** field will display the contents of that same field from the **Documentation** tab of the properties dialog for the selected Activity or Process. If enabled, the **View** button will attempt to launch your preferred web browser (for a URL) or suitable application for the file if it contains any path information. By providing easy access to key Activity or Process properties, this feature is ideal for use in model review and validation. (See "Common Activity Input Fields" on page 70.)

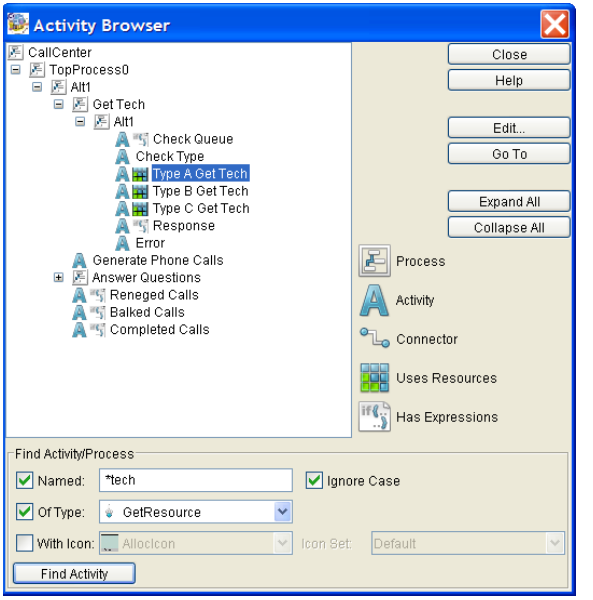


Activity Browser...

Activity Browser... is a feature for navigating among the Activities. A dialog lists all the Activities and Processes contained in the model. Any name preceded by a (+) signifies a hierarchical Process or a Process Alternative. Double-clicking on the Process or Process Alternative name will expand the tree diagram, displaying Activities and Processes underneath. Double-clicking on the Activity name will bring up the properties of the Activity. Each item has an icon that identifies the item as an Activity or a Process, and an icon that indicates whether the item has Expressions or Resources. Select an Activity and either **Edit** the Properties of that Activity or **Go To** the layer in the model layout where that Activity resides. **Expand All** expands the complete model hierarchy, and **Collapse All** restores the hierarchy to the top level.

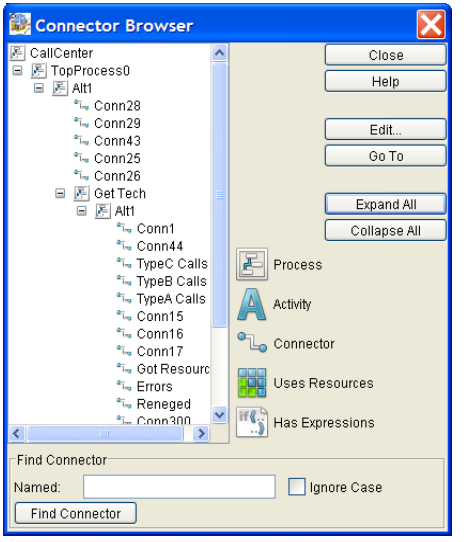


The **Activity Browser** can be used to search for specific Processes or Activities. There are three search criteria: Activity name, Activity type, or Activity icon. Each can be used individually or in combination. Search criteria that are combined are combined using "and" logic. The asterisk (*) can be used as a wildcard for name searches. The asterisk can go at the beginning of the search string, the end of the search string, or both. Wildcards cannot be used in the middle of a search string. Select **Ignore Case** to perform case insensitive searches. Selecting **Find Activity** finds the first Activity in the model hierarchy that matches the search criteria. Subsequent clicks of **Find Activity** will continue the search for the next match.



Connector Browser...

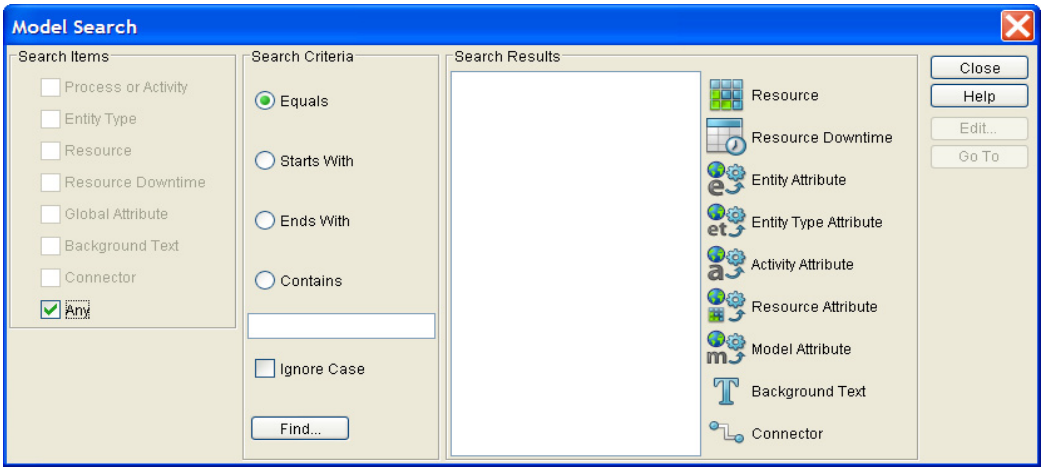
Connector Browser... is a feature for navigating among the Connectors. A dialog lists all the Processes and Connectors contained in the model. Any name preceded by a (+) signifies a hierarchical Process or a Process Alternative. Double-clicking on the Process or Process Alternative name will expand the tree diagram, displaying Connectors and Processes underneath. Double-clicking on the Connector name will bring up the properties of the Connector. Each item has an icon that identifies the item as a Connector or a Process. Select a Connector and either **Edit** the Properties of that Connector or **Go To** the layer in the model layout where that Connector resides. **Expand All** expands the complete model hierarchy, and **Collapse All** restores the hierarchy to the top level.



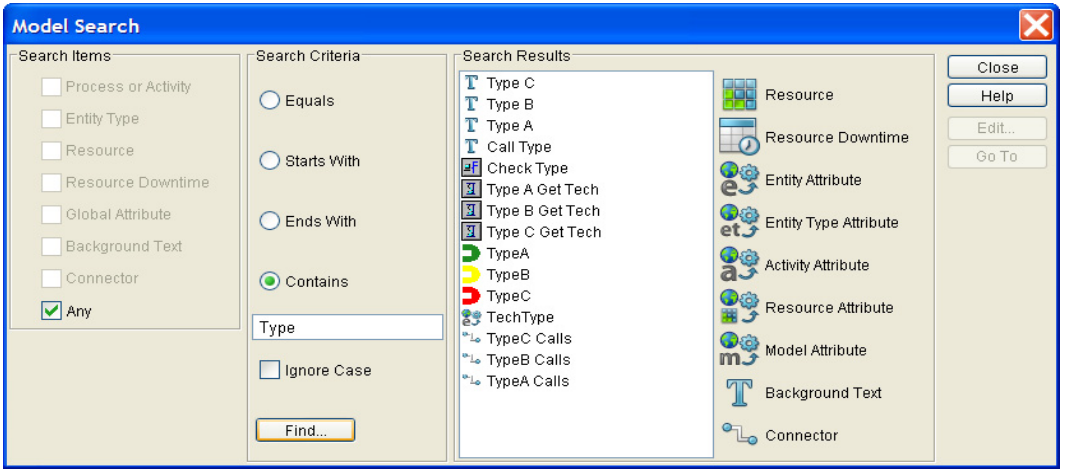
The **Connector Browser** can be used to search for specific Connectors by name. The asterisk (*) can be used as a wildcard for searches. The asterisk can go at the beginning of the search string, the end of the search string, or both. Wildcards cannot be used in the middle of a search string. Select **Ignore Case** to perform case insensitive searches. Selecting **Find Connector** finds the first Connector in the model hierarchy that matches the search criteria. Subsequent clicks of **Find Connector** will continue the search for the next match.

Model Search...

Model Search is a quick way of searching by name for items within the model. The **Model Search** dialog has three areas: **Search Items**, **Search Criteria**, and **Search Results**.



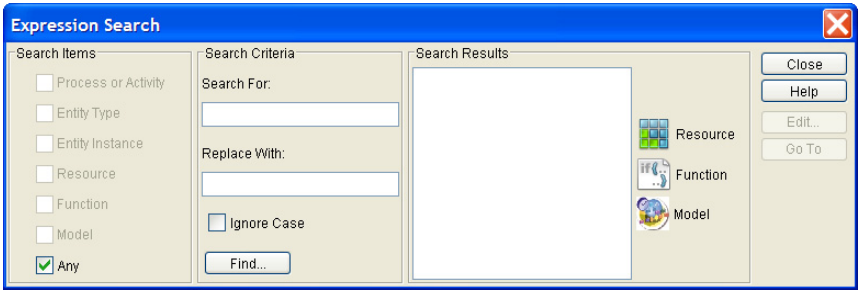
Search Items has eight check boxes: **Process or Activity**, **Entity Type**, **Resource**, **Resource Downtime**, **Global Attribute**, **Background Text**, **Connector**, or **Any** (default). The other items become available for selection when **Any** is deselected. **Model Search** searches the names of the selected **Search Items** based on the options set in **Search Criteria**. Enter the string to search for in the text field of **Search Criteria**, then select how to compare the string entered with the names of the selected **Search Items**. The options are **Equals**, **Starts With**, **Ends With**, or **Contains**. Select **Ignore Case** to perform a case insensitive search. Once the **Search Criteria** has been set, click the **Find...** button to perform the search. **Search Results** displays the items found. The type of each item found (Process or Activity, Entity Type, Resource, Global Attribute, Background Text, or Connector) is identified by an icon to the left of the name. Process, Activity, or Entity Type items display a scaled down version of their assigned icons. Resource, Global Attribute, Background Text, or Connector display an icon based on the legend to the right of the list. The example below shows a search on the `CallCenter.spm` demonstration model. The search was a case sensitive search for any names containing **Type**. Four background text items, four activities, three entity types, one global entity attribute, and three connectors were found.



Selecting an item will cause the **Edit...** button to activate. The properties of the item can be edited by clicking the **Edit...** button or by double-clicking an item. The **Go To** button will activate if the item selected is a Process or Activity. Selecting **Go To** will take you to the level of the model where that item is located.

Expression Search...

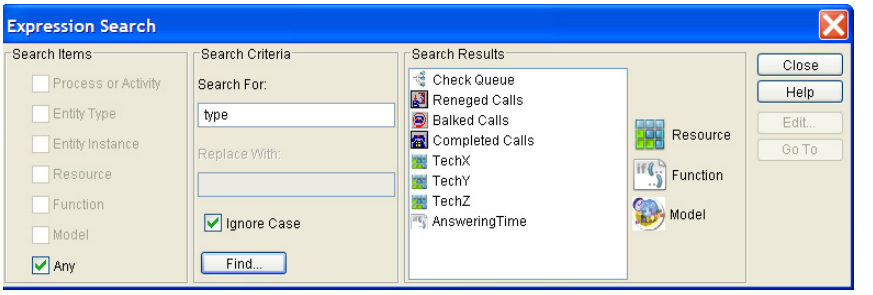
Expression Search is a quick way of searching for the existence of expressions or for expressions that contain specific text. Searching for text can also include replacing text. As with **Model Search**, the **Expression Search** dialog has three areas: **Search Items**, **Search Criteria**, and **Search Results**.



Search Items has seven check boxes: **Process or Activity**, **Entity Type**, **Entity Instance**, **Resource**, **Function**, **Model**, or **Any** (default). The other items become available for selection when **Any** is deselected. **Expression Search** searches the expressions of the selected **Search Items** based on the options set in **Search Criteria**. To find items that have expressions no matter what the text of the expressions, leave the **Search For** field empty. (Note that if the **Search For** field is empty, items that have Expressions stored

in files will be located.) To search for specific text in expressions, enter the search text in the **Search For** field. All searches are "contains" searches. That is, there is a match if the text in the **Search For** field is contained within any line of an expression. Select **Ignore Case** to perform a case insensitive search. If the **Replace With** field is not empty, the text in the **Search For** field found in expressions will be replaced with the text in the **Replace With** field. There is no undo for replace actions. Also, replace actions are case sensitive only. Selecting **Ignore Case** will empty and disable the **Replace With** field. Expressions stored in files are not included in searches when the **Search For** field contains text.

Once the **Search Criteria** has been set, click the **Find...** button to perform the search. **Search Results** displays the items found. The type of each item found (Process or Activity, Entity Type, Resource, Function, or Model) is identified by an icon to the left of the name. Process, Activity, or Entity Type items display a scaled down version of their assigned icons. Resource, Function, and Model display an icon based on the legend to the right of the list. The example below shows a search on the `CallCenter.spm` demonstration model. The search was a case insensitive search for any expressions containing **type**. Four Activities, three Resources, and one Function were found.



Selecting an item will cause the **Edit...** button to activate. The properties of the item can be edited by clicking the **Edit...** button or by double-clicking an item. The **Go To** button will activate if the item selected is a Process or Activity. Selecting **Go To** will take you to the level of the model where that item is located.

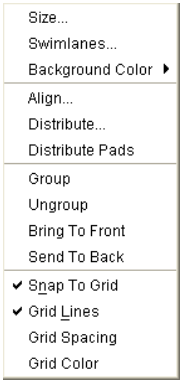
Metadata Search...

Metadata Search is a quick way of searching for the existence of metadata or searching for specific metadata. See Chapter 4 of the *SIMPROCESS Metadata Manual* for **Metadata Search** instructions.

Properties…

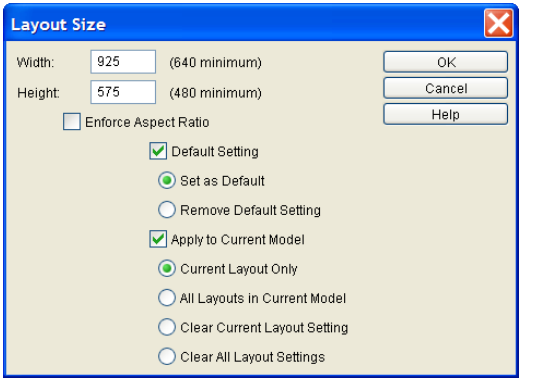
Selecting **Edit/Properties…** will bring up the **Properties** dialog box for the selected item. This has the same effect as double-clicking on it. Use this menu item most often when you want to edit Hierarchical Processes, since double-clicking on them will show their internal structure and not bring up their dialog box.

Layout Menu



Size... brings up a dialog that allows you to specify the size (in pixels) used in the drawing of model layouts. The layout is the area on the screen where models are built and displayed. The default setting is a width of 925 and height of 575. The size can be changed for the current session, saved and used for subsequent SIMPROCESS sessions, saved with the current model layout and always used to display it, or saved and used with all layouts in a model. Each time a layout is displayed, its stored size will be used. The session setting will be used if there is not a stored size.

Enforce Aspect Ratio defaults to not selected. If **Enforce Aspect Ratio** is selected, the ratio of height to width must be 0.75. Selecting **Enforce Aspect Ratio** will cause the default width of 925 and height of 575 to change to 928 and 626 respectively since 925 and 575 do not conform to the 0.75 ratio. This ratio is enforced whenever a change is made to the height or width. For example, if the height were changed to 712, the width would automatically change to 952, and the entered value of 712 would change to 714. Thus, both values are updated to the next higher values that meet the 0.75 ratio.



Width is the width of the layout in pixels (640 minimum).

Height is the height of the layout in pixels (480 minimum).

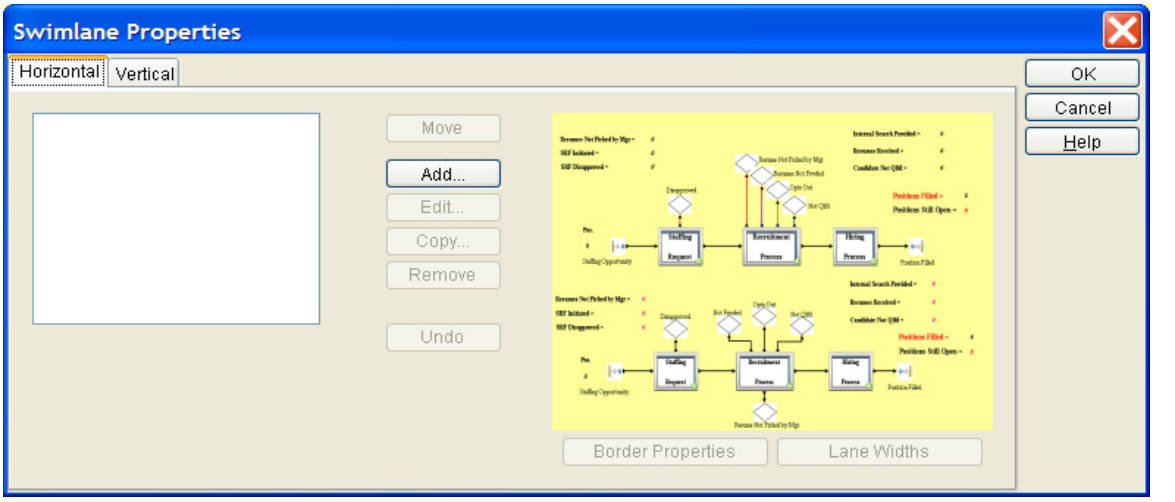
Default Setting either saves the entered width and height as the session default (**Set as Default**) and causes this size to be saved for use in future SIMPROCESS sessions, or it removes the saved session setting (**Remove Default Setting**) so that future SIMPROCESS sessions will use the 925 by 575 size. The setting used for the remainder of the current SIMPROCESS session (unless changed again via this dialog) will be the one specified here.

Apply to Current Model enables the following four options:

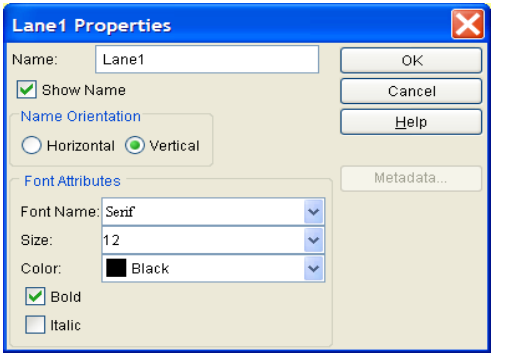
- **Current Layout Only** applies the entered values only to the active layout. The specified size of the current layout will be stored with the model when the model is saved.
- **All Layouts in Current Model** stores the entered values with all layouts in the active model so that they become permanent (if the model is saved).
- **Clear Current Layout Setting** removes a previously specified layout size for the current layout, so that the layout is subsequently redrawn (when necessary) using the current session layout size.
- **Clear All Layout Settings** removes stored layout sizes for all layouts of the current model. The layouts will subsequently display using the current session layout size.

The current session setting is only changed if no checkboxes are selected or if the **Default Setting** checkbox is selected. Each time a layout is displayed, if a layout size is specified in the model, that size will be used; if none is found, the current session setting will be used instead.

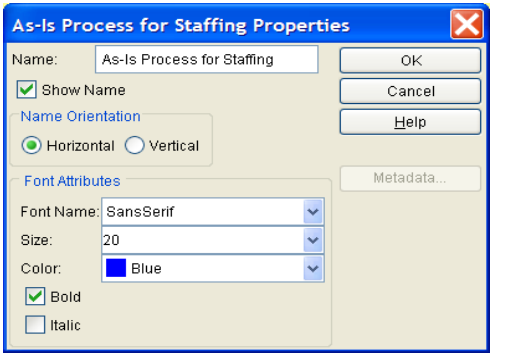
Swimlanes... allows you to add swimlanes to the current layout. The swimlanes dialog has two tabs: **Horizontal** and **Vertical**. On the left side of each tab is the list of swimlanes. The right side has a miniature view of the current layout. Note that more than one lane must be added for anything to appear on the miniature view or on the actual layout. Both horizontal and vertical swimlanes can be on the same layout. The example below shows a modified version of the demonstration model, `Human Resources.spm`.



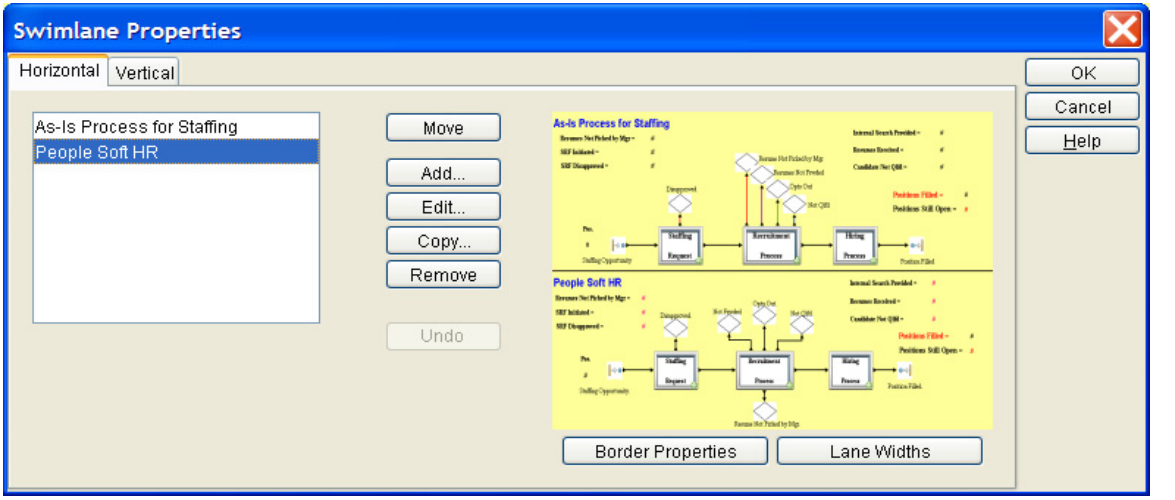
Click the **Add...** button to add a swimlane. This brings up a dialog which contains the name of the swimlane, whether the name should be displayed (**Show Name**), whether the name should be displayed horizontally or vertically (**Name Orientation**, horizontal swimlanes only), and the **Font Attributes** for the name.



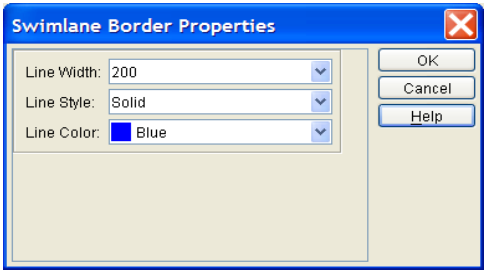
Edit the properties to set the appropriate name and display characteristics. The **Metadata...** button opens a dialog for entering metadata. See Chapter 4 of the *SIMPROCESS Metadata Manual* for a full discussion of entering SIMPROCESS metadata.



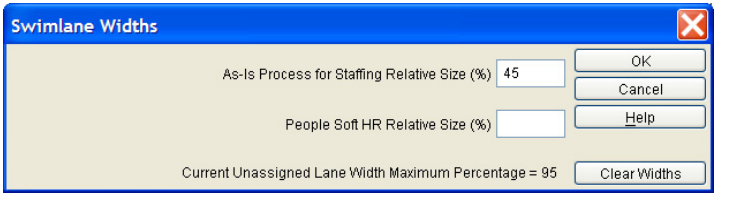
Adding a second swimlane causes a swimlane border to appear in the miniature view. Adding a third swimlane would cause a second swimlane border to appear. There is always one less border than swimlanes. The borders are evenly spaced down (or across for vertical swimlanes) on the layout.



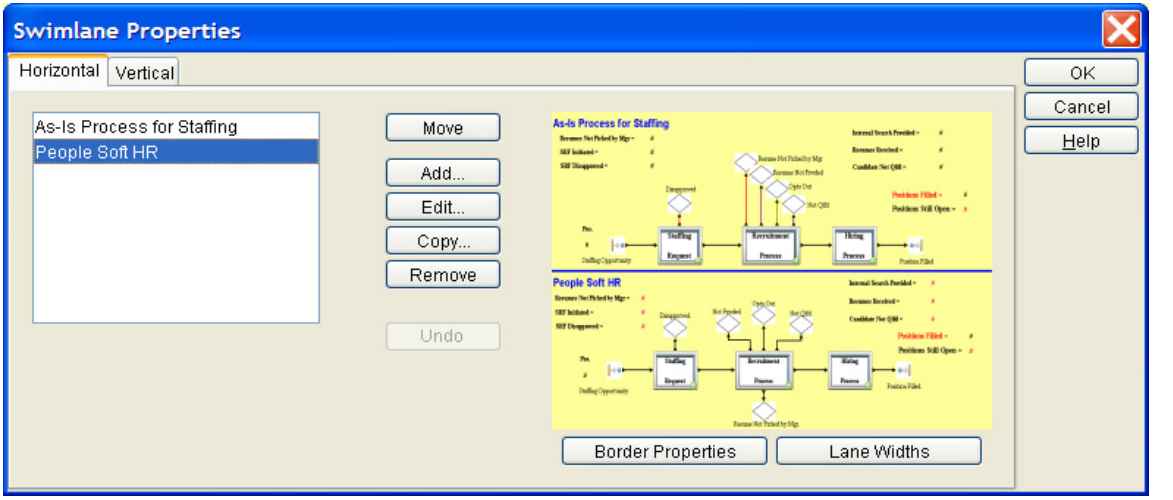
Once there are at least two swimlanes defined, the **Move** button and the two buttons below the miniature view activate. The **Move** button allows the rearrangement of the order of swimlanes without having to delete and recreate. The **Move** button causes the selected item to move down in the list. **Move** causes the item to go to the top of the list if the selected item is the last item. The **Border Properties** and **Lane Widths** buttons change the look of the borders and the widths of the swimlanes. **Border Properties** brings up a dialog that sets the **Line Width**, **Line Style**, and **Line Color** for each of the borders. The properties apply to the borders top to bottom for horizontal swimlanes and left to right for vertical swimlanes. Since there are only two lanes, there is only one border.



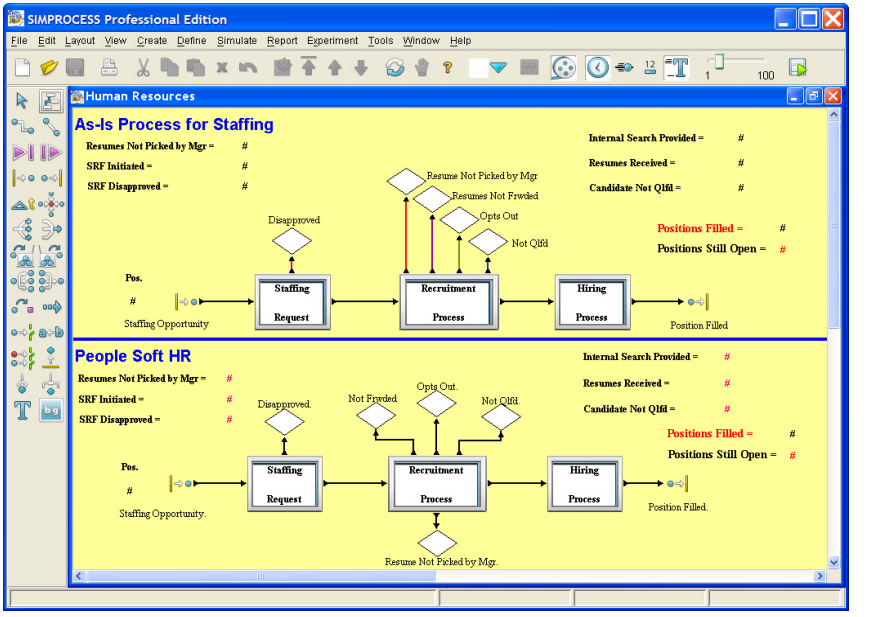
The **Lane Widths** button changes the widths of the swimlanes. The swimlane defaults to evenly spaced widths. Each swimlane will be 50% of the layout if there are two swimlanes. The dialog allows you to enter relative percentages for all or some swimlanes. Entries are not required for each swimlane. The minimum swimlane width is 5% of the layout. Swimlanes that do not have an entry will be evenly spaced across the remaining area of the layout. The **Current Unassigned Lane Width Maximum Percentage** shows the maximum value that can be assigned to a lane. **As-Is Process for Staffing** is assigned 45% of the layout area in the example below. This means 55% of the layout area is left for **People Soft HR**. The **Clear Widths** buttons removes all swimlane width assignments.



For the image below, adjusting the width removes the overlap of the **People Soft HR** swimlane title with the dynamic labels.



When **OK** is selected on the Swimlane Properties dialog, the swimlanes are drawn on the model layout. Note that swimlane borders or titles may not be edited by clicking on the layout. All edits must be done from the Swimlane Properties dialog.

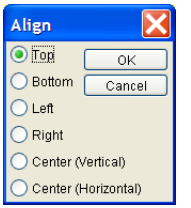


Background Color

Current Layout changes the background color of the visible layout to the selected color.

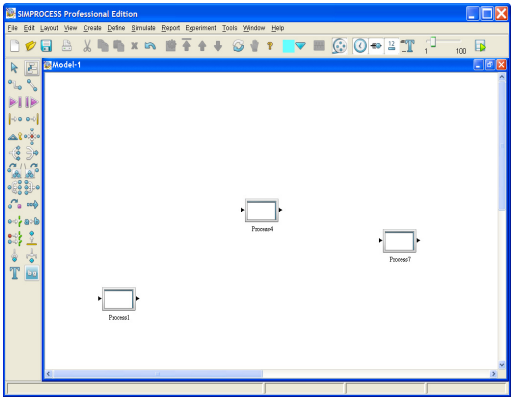
All Layouts changes the background color of all layouts in the active model to the selected color.

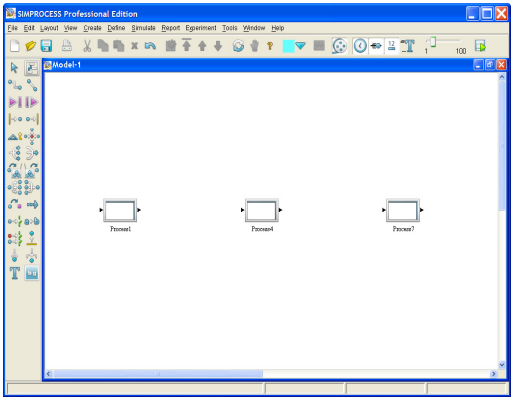
Align…



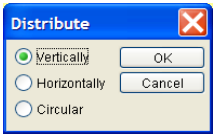
Aligns a number of selected objects according to various criteria.

Top aligns the tops of the selected objects.
Bottom aligns the bottoms of the selected objects.
Left aligns the left sides of the selected objects
Right aligns the right sides of the selected objects
Center (Vertical) aligns the centers of the selected objects along a vertical line.
Center (Horizontal) aligns the centers of the selected objects along a horizontal line.
The screen shots below show the effect of using **Align** before and after aligning the horizontal centers:





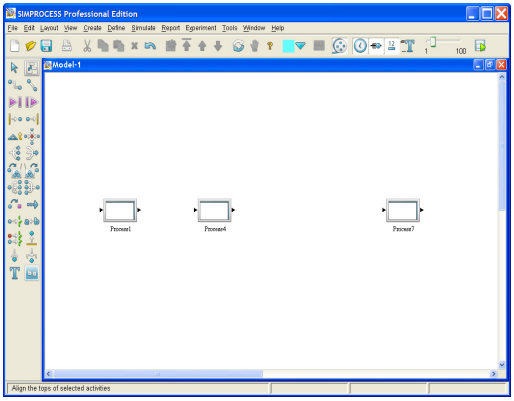
Distribute…



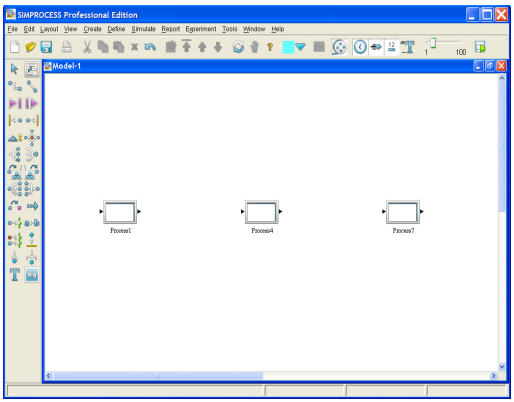
Distributes three or more selected objects so that they are equally spaced, vertically, horizontally, or circularly.

The screen shots below show the results of using **Distribute** on some unequally spaced objects.

Before using **Distribute**:



After using **Distribute**:



Distribute Pads

Pads added to a Hierarchical Process can be spaced evenly by selecting **Distribute Pads.** Although intended for the Hierarchical Process, this menu item can be used for any Activity or Process.

Group combines multiple objects into a *group*. All normal editing operations that can be done on an individual object can be done on the group. This can be useful when the model is divided into logical sections. A section can be grouped and then moved with respect to the other sections. A group can be cut from the layout, or copied and pasted to create an identical group.

Use **Ungroup** to edit individual components of a group.

Ungroup breaks up a group into the original components that went into making the group.

Bring To Front brings an object to the front of the layout so it can be edited.

Send To Back sends an object that is at the front of the model layout to the back.

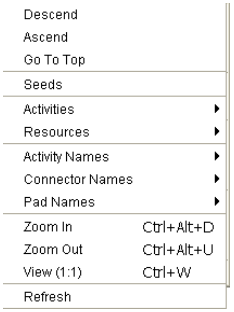
Snap To Grid. Once turned on, objects can only be placed on the layout at grid intersections.

Grid Lines places a grid on the model layout as a convenience in aligning objects. The grid has no significance to the model.

Grid Spacing changes the spacing of the grid. Three levels are offered: Fine, Medium, and Coarse.

Grid Color changes the color of the grid to the color selected on the color button.

View Menu



Descend takes the model down one level in the model hierarchy.

Ascend takes the model one level up in the Process hierarchy.

Go To Top takes the model to the top of the Process hierarchy.

Seeds is used for viewing the random number stream seeds.

Activities

Hide hides the selected Activity. The Activity and its Connectors to it will not be visible on the layout.

Show All makes all Activities and their Connectors visible.

Show Attached makes all the Activities that are connected to a selected Activity visible.

By Resource... allows you to view or edit resource Activity assignments.

By Time Stamp... allows you to view or edit Time Stamp key assignments at Activities.

Resources

By Activity allows you to view or edit resource usage by Activity.

Activity Names. These menu items only affect the display of Activity names. The changes are not saved with the model.

Show All makes all Activity names visible throughout the model.

Hide All makes all Activity names invisible throughout the model.

Local shows or hides Activity names based on their individual properties (set with the **Properties** dialog

Show Name checkbox). This is the default setting when a model is opened.

Connector Names

These menu items only affect the display of connector names. The changes are not saved with the model.

Show All makes all connector names visible throughout the model.

Hide All makes all connector names invisible throughout the model.

Local shows or hides connector names based on their individual properties (set with the **Properties** dialog **Show Name** checkbox). This is the default setting when a model is opened.

Pad Names

These menu items only affect the display of Pad names. The changes are not saved with the model.

Show All makes all Pad names visible throughout the model.

Hide All makes all Pad names invisible throughout the model.

Local shows or hides Pad names based on their individual properties (set with the properties dialog **Show Name** checkbox). This is the default setting when a model is opened.

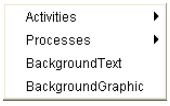
Zoom In magnifies a section of the layout to see more detail. Select **Zoom In** and click and drag the mouse to define the area on the layout to zoom.

Zoom Out is the reverse of **Zoom In**.

View (1:1) returns the layout window to its original size.

Refresh redraws the current screen.

Create Menu



Activities provides an alternative way of creating Activities, rather than graphically dragging and dropping them from the Layout Toolbar.

Activities added to a Library can be added to this menu and/or added to the Library Toolbar.

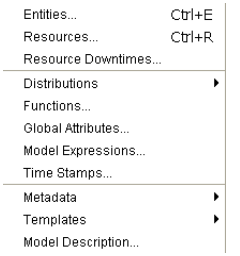
Processes provides an alternative way of creating Processes.

Processes added to a Library will be added to this menu.

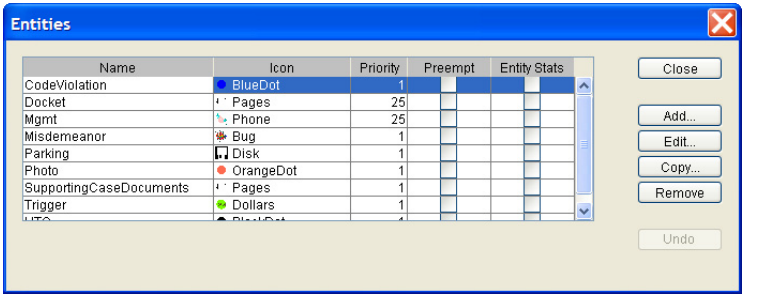
BackgroundText provides an alternative way of creating static or dynamic labels.

BackgroundGraphic provides an alternative way of changing the background.

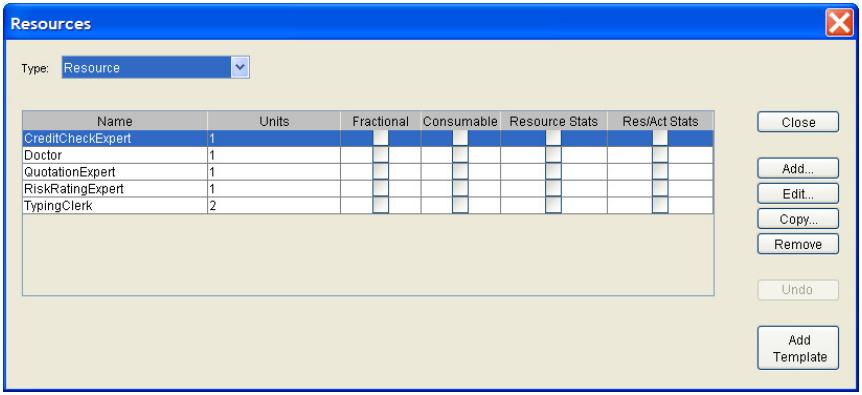
Define Menu



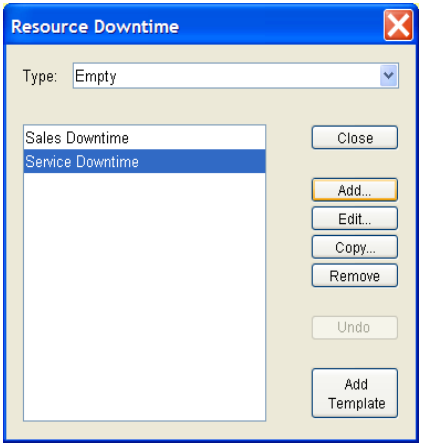
Entities… is used for managing Entity Types in the model.



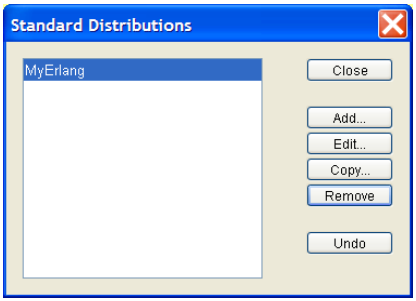
Resources… is used for managing Resources in the model.



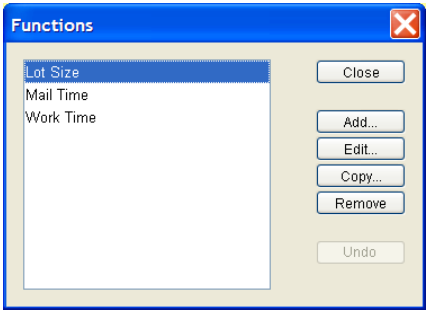
Resource Downtimes... is used for managing Resource Downtimes in the model.



Distributions is used for managing customized **Standard**, **Tabular**, and **Auto Fits Distributions**. Once a Distribution is defined, it can be used throughout the model without the need to redefine the parameters of the distribution. (See “User Defined Distributions” on page 98.)



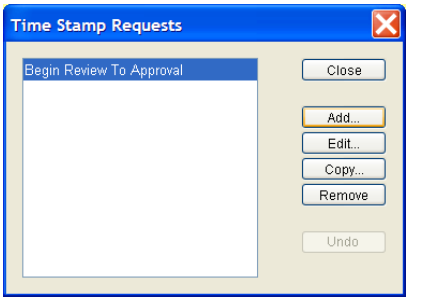
Functions… is used for managing **Functions** (Expressions that return a value). Functions defined here can be used throughout the model.



Global Attributes... is used for globally defining attributes for **Entity** instances, **Entity Types**, **Resources**, **Activities**, and the **Model**. See "Introduction to Attributes and Expressions," beginning on page 239 for more information on Attributes.

Model Expressions... defines customized Processing for the model at various points during a simulation. This topic is covered in detail in Chapter 10, "Customizing a Model with Attributes and Expressions," beginning on page 237.

Time Stamps… manages **Time Stamps**. **Time Stamps** can be used as event logs. (See "Event Logs" on page 362.)

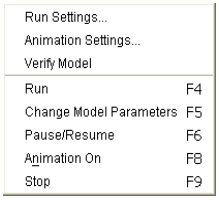


Metadata contains three sub menu items: **Launch Metamodel Editor**, **Assign Metamodels**, and **Model Metadata...**. **Launch Metamodel Editor** opens the SIMPROCESS Metamodel Editor. **Assign Metamodels** assigns a SIMPROCESS Metamodel to the active SIMPROCESS model. **Model Metadata...** is used to enter metadata at the model level. See the *SIMPROCESS Metadata Manual* for information on these topics.

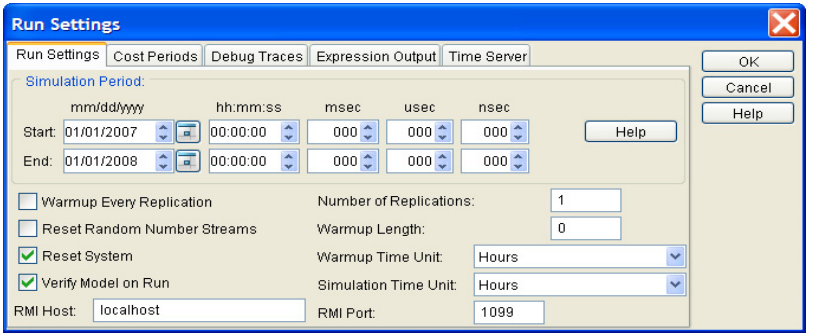
Templates defines and edits **Templates**. This option also allows saving templates to a Library or loading a new Library. See Chapter 9, "Reusable Templates and Libraries," beginning on page 223.

Model Description... provides a place to document the model. See "document Subdirectory" on page 474 for information on customizing the headings.

Simulate Menu



Run Settings...



Run Settings tab is used to set the run options for the simulation. (See "Run Settings" on page 109.)

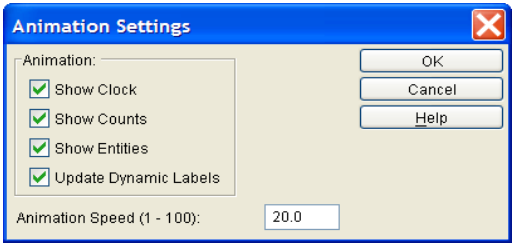
Cost Periods tab defines cost periods for Activity based costing calculations. (See "Setting Up Cost Periods" on page 179.)

Debug Traces tab defines trace files of entity actions for debugging purposes. (See "Debug Traces" on page 111.)

Expression Output tab offers options for the `OUTPUT` statement. (See "Expression Output" on page 112.)

Time Server tab allows the simulation time to be managed by the SIMPROCESS TimeServer. (See "Time Server" on page 113.)

Animation Settings...



Show Clock turns the simulation time clock on or off while the simulation is running.

Show Counts. If **Show Counts** is turned on, each Activity or Process will display a number above its icon.

- Generate Activities show the number of Entities generated.

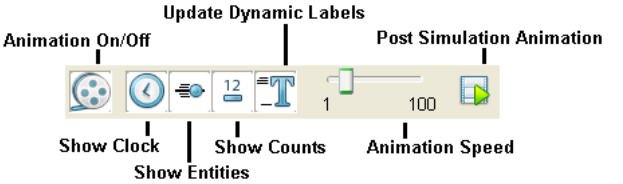
- Dispose Activities show how many Entities have been disposed.
- All other Activities and Processes show how many entities are in that Process or Activity.

Show Entities turns the display of Entities on or off during the animation. Showing Entities assists with visualizing the workflow.

Update Dynamic Labels turns the display of dynamic labels on or off during the animation.

Animation Speed. Changes the **Animation Speed** during the simulation. The fastest value is 100, and the default is 20. A smaller value is better while debugging the model.

The animation setting can also be changed by using the buttons and slider on the tool bar. A depressed button means the item represented by the button is turned on. Going from left to right, the buttons are **Animation On**, **Show Clock**, **Show Entities**, **Show Counts**, and **UpdateDynamicLabels**. The slider is for **Animation Speed**. The final button displays the post simulation animation controls. (See "Post Simulation Animation" on page 172.)



Run

Run verifies the model (if selected) and then starts the simulation running.

Change Model Parameters

This item, available only while running a model which has attributes identified as Model Parameters, will pause the simulation and allow parameter values to be changed. See "Running a Simulation with Model Parameters," beginning on page 91 for more information on Model Parameters.

Pause/Resume

If the simulation is running, it pauses the simulation. If the simulation is paused, it resumes running the simulation.

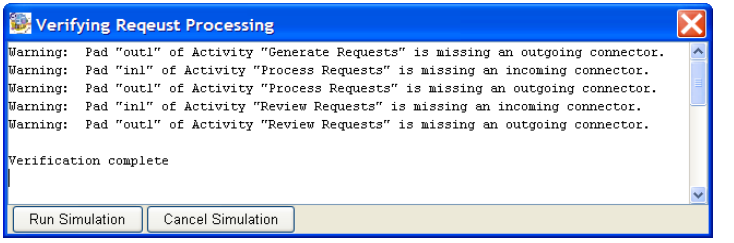
Stop stops the simulation and ends the collection of statistics.

Animation On

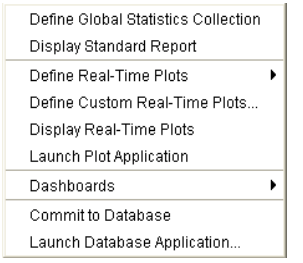
Animation On turns animation on or off, but does not turn on animation that is turned off in the **Animation Settings**.

Verify Model

Verify Model checks the model to see whether or not all the Activities are connected properly and if the model can be simulated. If this option is selected in the **Run Settings,** verification is done automatically when a simulation starts. A notification of any problems found will be displayed along with an option to stop the simulation.



Report Menu



Define Global Statistics Collection sets which statistics are collected during the model execution. See “Default Performance Measures” on page 186.

Display Standard Report views reports that contain the statistical results of the simulation run. See “Standard Report” on page 186.

Define Real-Time Plots sets which real-time plots to display during or after the simulation run. See “Defining Plots” on page 200.

Define Custom Real-Time Plots creates plots with multiple values to view during or after the simulation run. See "Custom Plots" on page 209.

Display Real-Time Plots selects real-time plots for viewing. See "Displaying Real-Time Plots" on page 203.

Launch Plot Application opens a blank plot window. Saved plots may then be opened for viewing. See "Displaying Plots Remotely" on page 204.

Dashboards Defines new dashboards for use with models, or **Assigns** previously defined dashboards to a model. See "SIMPROCESS Dashboards" on page 431.

Commit to Database saves simulation results in the SIMPROCESS database (SimProcDB). Commit to Database is described in detail in Chapter 13–SIMPROCESS Database, on page 375.

Launch Database Application starts the database application from within SIMPROCESS. The Manage Results form launches automatically when launching MS Access from this menu item. The Manage Results form is described in detail in Chapter 13–SIMPROCESS Database, on page 375.

Experiment Menu

Define Experiments sets up the experiments to run. The experiments are stored in the file `Experiments.xml`. Defining Experiments is described in detail in Chapter 14–Experiment Manager, on page 387.

Run All Experiments attempts to run every experiment defined.

Run Selected Experiments attempts to run experiments for which the **Selected** field is checked.

Run Specific Experiment enters an experiment name that SIMPROCESS will attempt to run.

Running experiments is described in detail in Chapter 14–Experiment Manager, on page 387.

Tools Menu

ExpertFit executes ***ExpertFit***, a data analysis application from Averill Law & Associates, which can be used to analyze data to determine the best standard statistical distribution fit.

OptQuest executes OptQuest optimization from OptTek. See Chapter 15–OptQuest for SIMPROCESS, beginning on page 401 for more information.

Remote has four submenus.

- **Start Local Dashboard Server** starts the Dashboard Server to run Dashboards locally. See "Displaying Dashboards" on page 447.
- **Start RMI Registry** starts the Java RMI Registry. **Start SPServer** will not activate until the Java RMI Registry has been started.
- **Stop RMI Registry** stops the Java RMI Registry.
- **Start SPServer** starts SPServer. SPServer must be started for External schedules to operate. See "Adding an External Schedule" on page 335.
- **Stop SPServer** stops SPServer.

Repair Cross-References. Cross references are used in SIMPROCESS models to track Entities, Resources, and Attributes so items cannot be deleted that are in use. Models developed in releases 3.0 through 3.1.1 could have invalid cross references. Recommend running this utility on models developed in release 3.0 through release 3.1.1. The action is applied to the active model.

Collect Model Metrics displays a list of metrics for the active model. The metrics can be saved to a file. Metrics include

Model Name

Number of each type of Activity (Delay, Generate, etc.)

Number of Process Alternatives

Number of Entities, Resources, and Plots

Number of each type of Expression

Number of each type of Attribute

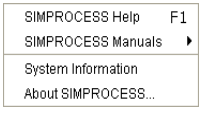
Icon Manager is used to import, export, and manage image files. A single image file can be imported for use as an icon, or multiple files (such as a directory of image files) can be imported. See "Importing Graphics Image Files" on page 168.

Manage Background Images is used to import, export, and manage background image files. See "Background Images" on page 168.

Window Menu

Displays a list of open models. Allows you to change which model is active.

Help Menu



SIMPROCESS Help displays a list of main help topics.

SIMPROCESS Manuals opens the *SIMPROCESS Getting Started Manual*, the *SIMPROCESS User's Manual*, and the *SIMPROCESS Metadata Manual*. These PDF files are the complete documentation set for SIMPROCESS. They will open using the application designated for PDF files by the platform on which SIMPROCESS is installed. On Linux systems, there must be a `view.properties` file as described for the **View** button on the **Documentation** tab of Activity and Process properties dialogs. (See "Common Activity Input Fields" on page 70.)

System Information displays a dialog that lists the relevant system information. It also includes a **Run GC** button. This button calls Java garbage collection and updates the Java memory information.

About SIMPROCESS displays information about SIMPROCESS, including the version, the copyright, and technical support information.

CHAPTER 2

SIMPROCESS Basics

A SIMPROCESS model contains the following components:

- Processes
- Activities
- Entities
- Resources
- Connectors
- Pads

Processes and ***Activities*** represent business operations in a SIMPROCESS model. SIMPROCESS models can be arranged in a hierarchy, with Processes encompassing other Processes and Activities.

SIMPROCESS Components

Processes

A set of ***Processes*** can represent the operation of a business at a very high level. This level represents only an outline of the business Process.

Activities represent the details of business operations. For example, in a mail order fulfillment operation, when a customer order is received, processing steps might include:

1. Identifying the customer.
2. Creating or accessing a customer profile.
3. Verifying the customer profile against information contained in the customer's order.

Each of these steps can be modeled as an Activity. Collectively, they comprise a single Process that might be called "Access/Create Customer Profile."

The Process construct allows a business Process to be broken down into successively more detailed layers.

A Process can be (and usually is) composed of other Processes and Activities. Activities cannot be decomposed.

Activities

SIMPROCESS contains a suite of ***Activities***, each reflecting a different type of action. Actions can be physical or logical.

Entities

Entities are objects that circulate through the model. They represent things (e.g., parts, deliveries, people) and information (orders, service requests, etc.) that flow from Activity to Activity. The customer order is an Entity in the order fulfillment process.

Unlike Processes and Activities, which appear as icons in the model layout, Entities aren't visible until a simulation is run. During the simulation, they emerge as icons flowing through the model, if animation is turned on.

Resources

Resources are the agents that add value to Entities or perform work at Activities. Examples include:

- A customer calls in an order, which requires a clerk to handle it. Order entry is the Activity, the order is an Entity, and the clerk is a Resource.
- A truck is required to deliver merchandise to the customer; the truck is a Resource.

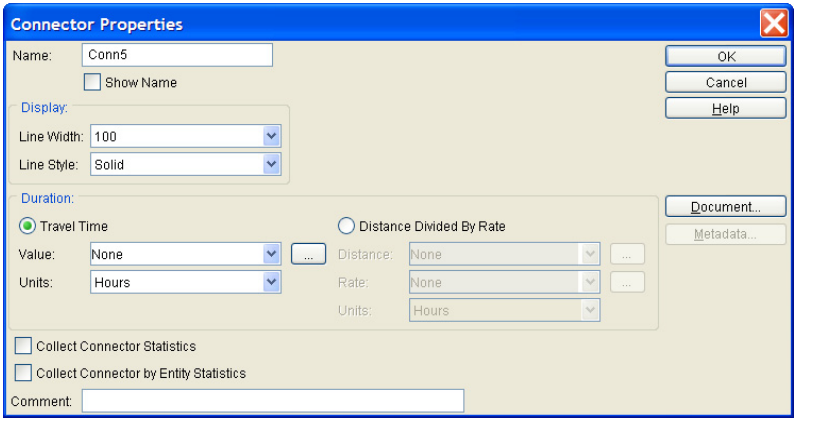
The way to minimize cycle time and Activity costs is by experimenting with different levels of Resources and different costs.

The availability of a Resource affects the amount of time it takes an Entity to flow through the Process. Lack of Resources can be a cause of bottlenecks in a business Process. A customer order might arrive while two clerks are busy handling other tasks. Order fulfillment is delayed until a clerk becomes available. The amount of time the customer order spends waiting for an available clerk is shown in the Entity Cycle Time by State output report as Wait for Resource. Another way to describe this situation is that the order waited in a queue for the available Resource.

Knowing how Resources are used is a key factor in understanding and improving upon the way a business operates.

Connectors

Connectors link Activities and Processes together and are the paths used by Entities to flow through the model. Connectors can have delay times.



Connector Names

A default Connector name, e.g., Conn44 is assigned. To change the Connector Name, edit the **Name** field in the Connector properties.

Displaying Connector Names

The **Edit Preferences** option, on the **Edit** menu, determines if names of new Connectors are displayed in the model. However, individual **Connector** dialogs have **Show Name** check boxes that will override the model default.

The **Name** field is displayed across the middle of the Connector if **Show Name** is selected.

Display Properties

The **Line Width** and **Line Style** properties control the appearance of the Connector. Defaults for **Line Width** and **Line Style** can be set in the **Preferences**. See “Preferences” on page 30.

Duration

A Connector defaults to no **Duration**. **Duration** can be specified by setting a **Travel Time** or by **Distance Divided By Rate**. If using **Distance Divided By Rate**, a value must be set for **Distance** and **Rate**, and **Rate** must not be zero. No units are assumed for **Distance** or **Rate**. The **Units** field applies to the value that results from **Distance** being divided by **Rate**.

Note that a Connector **Duration** affects Entity animation. When no Connectors on a layout have a **Duration**, one Entity moves at a time. This is because the Entity movement occurs in zero simulation time. However, when Connectors on a layout have a **Duration**, multiple Entities can be moving at the same time since the movement represents the passing of time. If some Connectors on a layout have a **Duration** and some do not, the movement of Entities on Connectors with a **Duration** will stop while Entities cross Connectors with no **Duration**. The **Units** set for **Travel Time** or **Distance Divided By Rate** also affect the animation of Entity movement. It is recommended (for animation purposes only) that the **Units** of the Connector **Duration** match the **Simulation Time Unit** on the **Run Settings** dialog. (See “Setting the Simulation Time Unit” on page 89.) If the **Simulation Time Unit** is different from the **Units** of a Connector **Duration**, then it is possible that either the Entities will move very slowly across the Connector no matter what Animation Speed (page 57) is set or the Entities will never show up (again, no matter what Animation Speed is set). If animation is not a consideration, then any value for **Units** is valid.

Connector Statistics

Collect Connector Statistics and **Collect Connector by Entity Statistics** are used to request statistics for the specified Connector. See “Connector Statistics,” beginning on page 198 for more information.

Pads

Pads are small triangular objects attached to Activities and Processes which serve as attachment points for Connectors. A single Pad can connect one or (possibly) more Connectors. Entities flow in one direction, entering nodes at input Pads and exiting at output Pads. Three sizes of Pads are available: small, medium, and large. The Pad size can be changed on the Pad properties dialog, or by right clicking on the Pad and choosing **Pad Size**. The size of all the Pads on an Activity or selected Activities can be changed by right clicking on a selected Activity and choosing **Pad Size**.

Pads also connect one level of a Process hierarchy to another. Pads can be queueing areas for Entities waiting for a Resource or condition.

Putting it Together

A SIMPROCESS model shows a business Process as a set of Nodes (Processes and Activities) connected by Connectors. Entities are generated from one or more Generate Activities, traverse the model, and finally proceed to a Dispose Activity, where they are disposed. Entities pass through other Activities, such as Delays and Branches.

A model is built by supplying numeric and symbolic attributes to the various Activities and the Entities that are processed at these Activities. The Resources needed to process the Entities are also defined.

The end result is a dynamic model of the business Process. Bottlenecks can be seen as they occur when simulations are run on this model. Reports and statistics may be generated describing the flow of people, materials, and information and quantifying how Resources are used. The model may continue to be modified in order to experiment with different scenarios.

A simple model can be built with just three Activity objects: Generate, Delay, and Dispose.

All models require a Generate Activity to generate Entities and a Dispose Activity to end the processing of Entities. Delay Activities are used to represent actions.

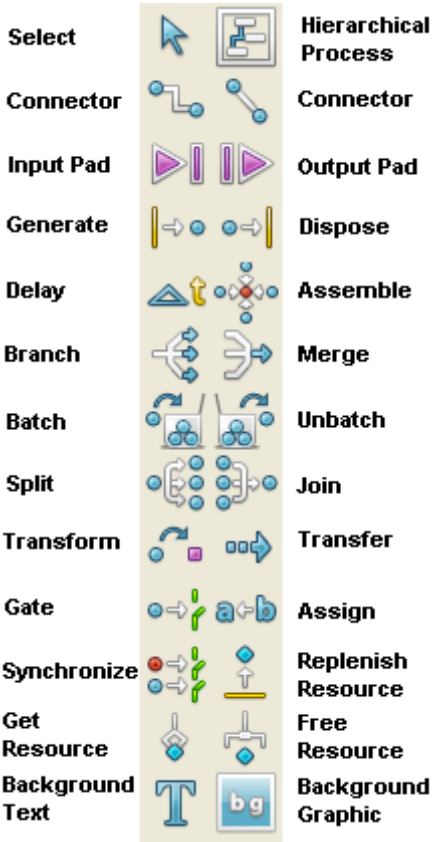
There are some things that are common to most Activities, such as the Activity name and Resources required by the Activity. This chapter begins with a discussion of the input fields and command buttons used to define these items. The remainder of the chapter describes the core SIMPROCESS Activities in detail, with particular attention devoted to the Generate Activity and

the Entities.

The remaining SIMPROCESS Activities are described in Chapter 4–Activity Modeling Constructs, beginning on page 118, and in “Explicitly Getting and Freeing Resources” on page 155.

Using the Layout Toolbar to Create Activities

The Layout Toolbar is the two columns of buttons running down the left margin of the SIMPROCESS window. These buttons are used to place model building blocks on the SIMPROCESS layout — the central region of the SIMPROCESS window.



Begin by adding a Generate Activity to the model. Click once on the Generate Activity button.

Next, point and click on the SIMPROCESS layout. A Generate Activity icon is added at that location.

Press and hold the **Shift** key while clicking on the layout to add several activities of the same type, i.e., Generate. Each time the layout is clicked, a Generate icon is added to the layout. Release the **Shift** key before dropping the last icon or click once on the Select tool to deactivate the Generate

button.

Removing Objects from the Layout

Select an object such as an Activity icon from the layout and press the **Delete** key. Several items may be removed at one time by drawing a rectangle around the objects and pressing **Delete** or selecting **Edit/Clear** from the menu or the popup menu.

Common Activity Input Fields

Activity Properties dialogs have the following common input fields:

- **Name** is the name chosen to identify the Activity. This name appears below the Activity, and it can be moved on the layout.
- **Icon** identifies the graphic icon representing the Activity.
- **Comment** is a one-line comment about the Activity. This comment appears in the status bar when the Activity is selected.
- **Documentation** tab contains a **Document...** button that opens an edit window for adding descriptive text about the Activity. See "document Subdirectory" on page 474 for information on customizing headings. Next to the **Document...** button is the **Metadata...** button. The **Metadata...** button opens a dialog for entering metadata. See Chapter 4 of the *SIMPROCESS Metadata Manual* for a full discussion of entering SIMPROCESS metadata. This tab also contains a field for adding a link to a URL or another document. (See "Export" on page 23.) The **View** button launches the preferred web browser if **Is URL** is selected. If **Is URL** is not selected, SIMPROCESS assumes the URL is a file and will attempt to open the file with whatever program is designated to open that type of file. For Windows, the **View** button enables when **Is URL** is selected and the **URL/File** field is not empty, or **Is URL** is not selected and the **URL/File** field indicates a path (contains backslashes or begins with `./`). The same conditions apply on Linux systems. In addition, on Linux, the `view.properties` file must be in the `SPUser` directory, and the `view.properties` file must contain valid `url.view` and `file.view` properties. Due to other applications being required, the **View** button is not guaranteed to work in every case.
- **Attributes** define custom attributes that the Activity requires. This topic is covered extensively in Chapter 10, "Customizing a Model with Attributes and Expressions," beginning on page 237.

- **Expressions** allow customized processing for the Activity at various points during a simulation. This topic is covered in detail in Chapter 10, "Customizing a Model with Attributes and Expressions," beginning on page 237.
- **Event Logs** are used for defining timestamps and recorders.
- **Text Block** is a three-line description that appears within the Activity's icon on the layout.
- **Help** displays information about the Activity.

The following tabs and fields are found on most Activity Properties dialogs:

- **Resources** defines the Resources required to process Entities arriving at the Activity. The Entity waits in a queue until the Resource or Resources can be obtained.
- **Duration/Value** is the amount of time it takes the Activity to process an Entity, once the required Resources are obtained. Time can be defined as a constant, or as a statistical distribution.
- **Duration/Time Units** specifies the units and measure for duration time in nanoseconds, microseconds, milliseconds, seconds, minutes, hours, days, weeks, months, or years.

The following buttons are found on all Activity Properties dialogs except Background Text. These buttons allow the creation of items that are then available throughout the model.

- **New Entity** creates new Entity types.
- **New Resource** creates new Resource types.
- **Entity** creates new global Entity instance attributes.
- **Entity Type** creates new global Entity Type attributes.
- **Resource** creates new global Resource attributes.
- **Model** creates new Model attributes.

Attributes are covered extensively in Chapter 10, "Customizing a Model with Attributes and Expressions," beginning on page 237.

Naming Activities

Use the **Name** field to assign a name to an Activity. This name is shown below the Activity icon in the model if the **Show Name** checkbox is selected.

SIMPROCESS assigns new Activities a default name. It is a good idea to change this to a name that

is meaningful; one that indicates what occurs at this Activity. Activities can be named just about anything, as long as the same name is not used twice in the same level of the model hierarchy.

Change the name of an existing Activity by clicking in the **Name** field and typing the new name.

The contents of the **Text Block** can be used as the **Name** by selecting the **Use Text Block** check box. The lines of text are appended together with a space between each line to create the **Name**. When **Use Text Block** is selected, the **Name** field is not editable. The values on the **Text Block** tab must be changed to change the **Name**.

Choosing an Icon

The **Icon** field identifies the graphical icon used to represent the Activity in the model layout. All Activity icons are arranged into sets. The set consists of predefined sets and user defined sets. (See "Importing Graphics Image Files" on page 168.) The **Icon Set** field lists the sets of icons available. The set **All** lists all icons regardless of set. Every Activity has several icons from which to choose. The names of the standard icons differ slightly for each Activity, because they include the name of the Activity.

Point and click on and icon's name to select it. The icon button on the right gives a reduced view of the icon. Click the icon button to see the actual size. GIF, JPG, and PNG files may be imported and used as custom icons for Activities.

Adding a Comment

Use the **Comment** field to add a brief comment describing the purpose of this Activity. This field is optional. Printing **Process Documentation** or **Model Documentation** will include comment in the document. The comment will appear on the status bar when an Activity is selected.

Documenting the Activity

The **Document** button opens an editor in which descriptive information may be added about the Activity. The editor opens with a preformatted template which is changeable. (See "document Subdirectory" on page 474.) Print **Document** text using the SIMPROCESS Print facility.

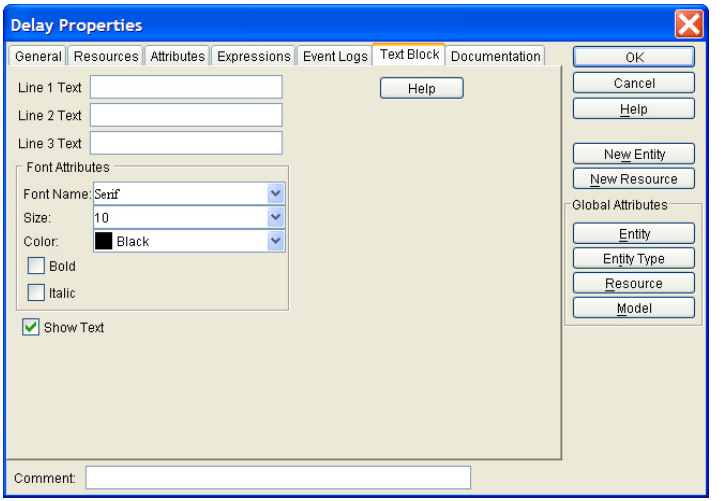
Labeling with Text Blocks

The Text Block tab adds up to three lines of text to the inside of the icon on the layout.

Text Block labels facilitate understanding of the Activity or Process in relation to the model.

Add descriptive labels to an icon by performing the following tasks:

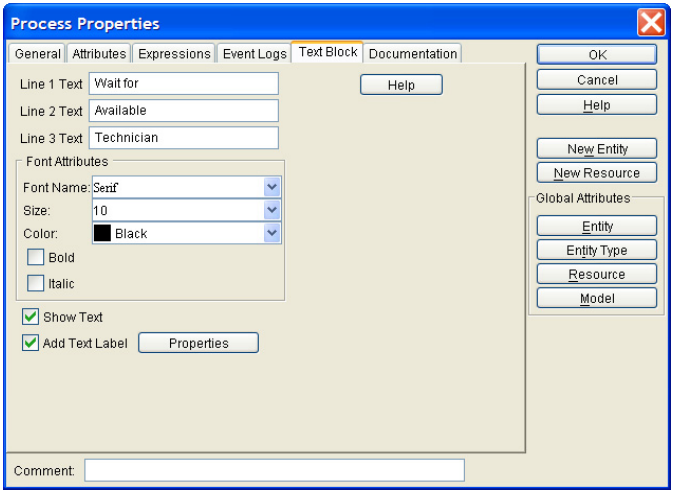
1. Click on Text Block tab:



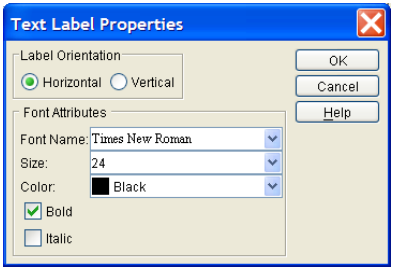
2. Fill in one to three lines of text.
3. Set the desired font attributes.
4. *Make sure the* **Show Text Box** *is checked*. The text entered is not displayed in the model unless this box is not checked.
5. Click on **OK**.

Note: The **Text Block** is best used with blank box icons. Icons with a picture on them will not show the **Text Block** properly.

Process properties include an additional option on the **Text Block** tab. The **Add Text Label** check box places a label that contains the text of the **Text Block** inside each alternative of the Process.



The lines of text are appended together with a space between each line to create the label. Select the **Properties** button to set whether the label should be displayed horizonally or vertically and to set the **Font Attributes** of the label.



The label will be centered across the top of the layout when **Horizontal** is selected, and the label will be centered along the left of the layout when **Vertical** is selected. Note that the labels cannot be resized or moved. Changes can only be made from the **Text Block** tab of the Process properties dialog. Defaults for **Horizontal** or **Vertical** and the **Font Attributes** can be set on the **Text Label** tab of the Preferences dialog (**Edit/Preferences**).

Getting Help

The Help button displays information about the purpose of the Activity and the fields and buttons on the **General** tab of the dialog. The other tabs have Help buttons that are specific to that tab.

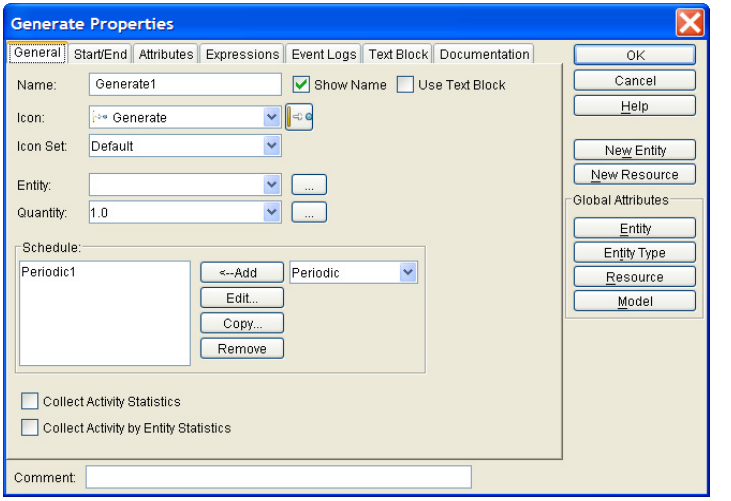
Generate Activity

Generate Activities create Entities for a model during a SIMPROCESS simulation. Generally, the first Activity defined in the model is a Generate.

SIMPROCESS generates Entities at the rate defined in the Generate Activity. Entities can be generated at a constant number and rate, such as a specified interval of time, or according to a statistical distribution. The schedule of generation can be as simple as one constant rate, or as complex as dozens of different rates depending on the hour of the day, day of the week, season of the year, etc.

A Generate Activity can generate one or more types of Entities

Defining a Basic Generate Activity



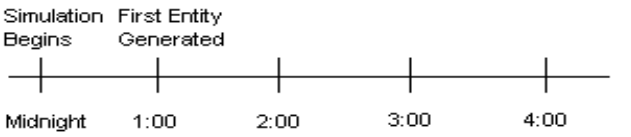
Click on the **Entity** pull-down arrow to select the default type of Entity to be generated by this Generate Activity. The default Entity type can be overridden in each schedule.

Entities may be defined using the **New Entity** command button on this dialog.

Use the **Quantity** field to specify the default number of Entities to be generated each time Entities are released. A specific number or probability distribution can be entered in the **Quantity** field or a selection may be made from the **Quantity** pull-down list. The default quantity can be overridden in each schedule.

A periodic schedule is the default schedule. The periodic schedule sets the interval and the time unit. It will default to an interval of 1.0 and time unit of Hours. These defaults can be changed by selecting the schedule (Periodic1) and choosing **Edit**. Change the name of the schedule, override the default Entity type and quantity, and set the interval and time unit with this method.

The **Interval** field defines the time between Entity generation events. Enter a constant value or a statistical distribution. Entities are generated at the end of each interval:



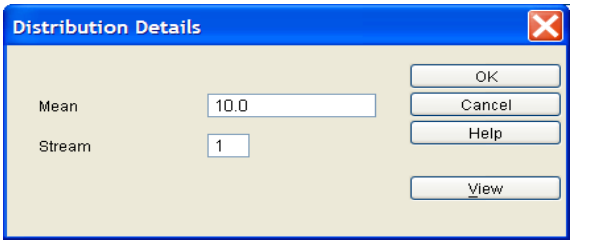
Entity Generation at Intervals of 1 hour

For example, assume Customer Orders to arrive at an exponential rate, with an average of 20 arrivals per hour. Click on the **Interval** pull-down arrow and find the definition for Exponential Distributions. It reads:

Exp(10.0)

Select the distribution. Then, click on the details button to the right of the pull-down arrow.

This displays a dialog for defining the parameters of the distribution:

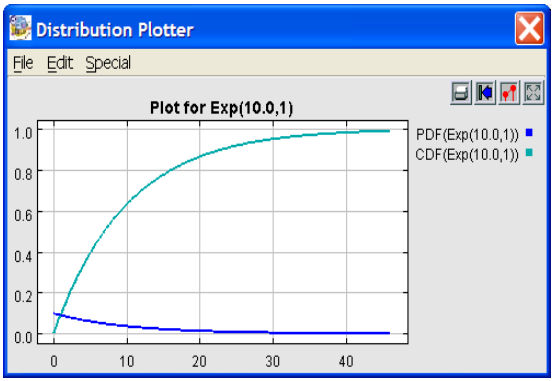


Set the **Mean** value to indicate an average Entity generation rate of 20 per hour.

Assume that Quantity is 1, meaning that only one Entity is produced at each Entity generation event:

- Generate an Entity every 3 minutes to get 20 Entities in an hour (60 minutes).

The **View** button displays a graphical representation of the distribution:

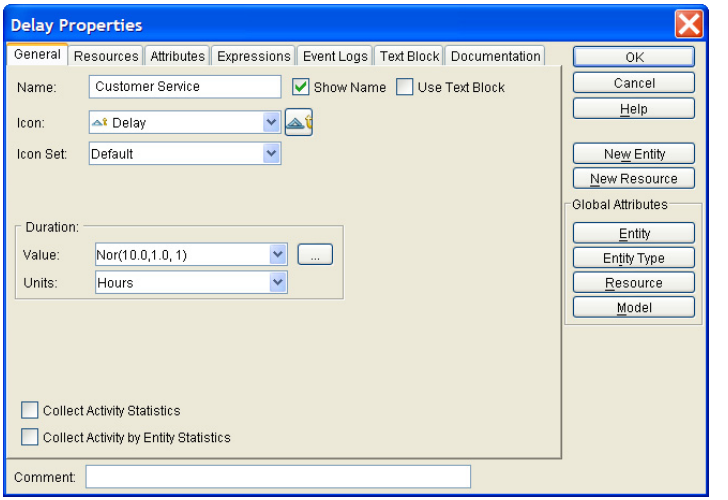


Stream identifies the random number stream used to seed the distribution.

More can be learned about statistical distributions and random number streams in Chapter 3, “Statistical Modeling Constructs,” beginning on page 94.

Delay Activity

Delay Activities, common building blocks found in most models, have two functions: they represent the passage of time during simulation and define the Resources required to perform a task. The cycle time of an Entity traversing the model is the sum of the delays it encounters, i.e., the time spent at the Activities in its path plus any hold time for a condition to be met and the wait time for any Resources.



The **Resources** button opens a dialog for specifying the Resources required to perform an Activity. See Chapter 5, “Resource Modeling Constructs,” beginning on page 147 for instructions on defining Resource requirements for an Activity.

Specifying Delay Duration

Value represents the amount of time required to perform an Activity. This delay time can be expressed as either a constant value or a statistical distribution.

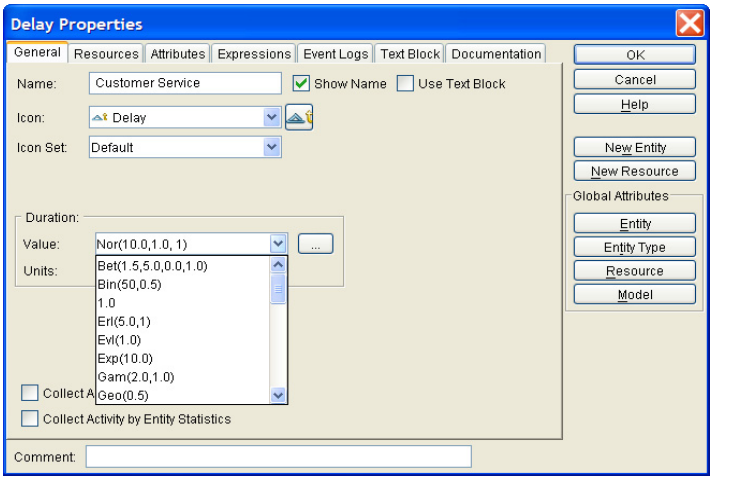
Time **Units** determines if the **Duration** entered is measured as nanoseconds, microseconds, milliseconds, seconds, minutes, hours, days, weeks, months, or years.

Type the value of the delay duration directly in the field, or select a value from a pull-down list.

A Delay Activity might be defined to represent the task of processing an order. This task takes an average of 30 minutes to perform, though it may take as little as 15 minutes, or as much as 1 hour.

As shown below, a Triangular distribution is often used to represent the time required to complete a task:

1. Click on the arrow to the right of the **Value** field to display a list of distributions:



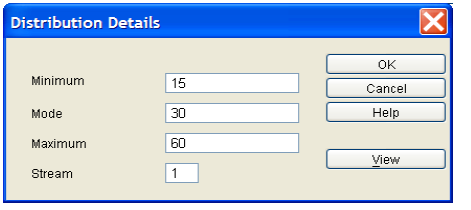
2. Scroll through the list to find the default definition for Triangular distributions. It reads:

   Tri(0.0,5.0,10.0)

   Select the distribution.

3. Click on the box to the right of the **Value** field. Fill in the following values:

   - **Minimum** of 15**, Mode** of 30, and a **Maximum** of 60.
   - Select **Minutes** from the **Units** field.



4. Click on **View** to see what the curve looks like.

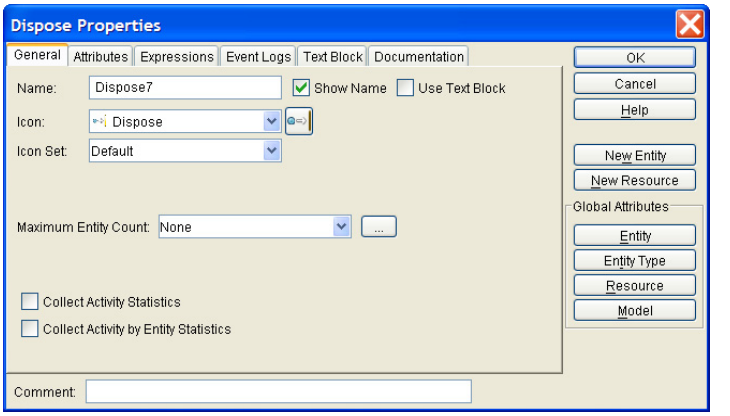
5. Click on **OK** to accept the definition.

See Chapter 3, “Statistical Modeling Constructs,” beginning on page 94 to learn more about these parameters and the topic of statistical distributions.

Dispose Activity

A Dispose Activity disposes of Entities when they are no longer needed in the simulation. The Dispose marks the end of an Entity's cycle time for the purpose of statistic collection (e.g., cycle times and counts).

Dispose Activity Properties



The **Dispose Activity Properties** dialog contains only one unique field: **Maximum Entity Count**. Use this field to set a limit to the number of Entities that can be disposed of at the Dispose during a simulation. The simulation ends if this limit is reached. End a simulation after 1,000 customer orders are processed by setting **Maximum Entity Count** to 1,000.

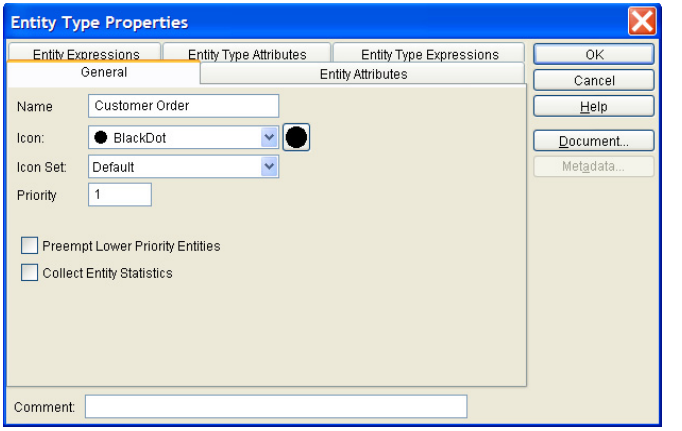
Leaving **Maximum Entity Count** undefined or setting a value of 0 or "none" indicates that there is no limit.

Defining an Entity

A particular *type* of Entity or a particular *instance of* an Entity may be referred to in the model. When an Entity type is referred to, all Entities of a particular type, e.g., customer orders are also referred. An Entity instance refers to an individual Entity (a single customer order).

Defining Entities in SIMPROCESS defines a type; SIMPROCESS generates instances of that Entity during a simulation run. Define Entities in the following manner:

1. Click on **Define** on the SIMPROCESS menu, and then select **Entities...** from the pull-down menu.
2. Click on **Add** to define a new Entity.



3. Specify the **Entity Type Properties**:

   - Entity **Name** identifies the type of Entity. **Name** can be any unique entity name.

     Double-click on the default name supplied by SIMPROCESS, and enter **Customer Order** as the Entity **Name**.

   - Entity **Icon** is the icon which will represent this Entity during a simulation run. The icon appears during simulation if the **Animation** option is on.

     Click on the downward-pointing arrowhead next to the Entity **Icon** field to get a list of different icons to choose from the currently selected **Icon Set**.

   - **Priority** values range from 1 to 100. When Entities contend for the same Resource, the Entity with the highest priority gets precedence.

- **Preempt Lower Priority Entities** sets whether instances of this type will preempt lower priority Entities. If true, when an instance of this type reaches an Activity that uses Resources and there are no Resources available, and the Entity currently using the Resources is a lower priority Entity, this higher priority arriving entity instance will cause the lower priority Entity to release the Resources so this Entity can obtain the Resources and Process.

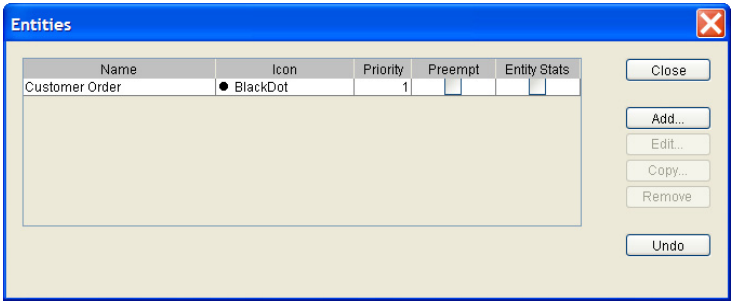
- **Entity Attributes**, **Entity Type Attributes**, **Entity Expressions**, and **Entity Type Expressions** are used in association with any attributes or expressions defined for this Entity. A choice can be made to create a new copy of an attribute or evaluate an expression every time an instance of an Entity is created. Alternatively, one copy of an attribute can be created or an expression evaluated once for an Entity type and have all instances refer to this value. Attributes and expressions are discussed in Chapter 10, "Customizing a Model with Attributes and Expressions," beginning on page 237.

- **Document...** opens an editor window into which extensive comments can be entered about the Entity and the model. This is optional. The Entity document headings can be customized. (See "document Subdirectory" on page 474.)

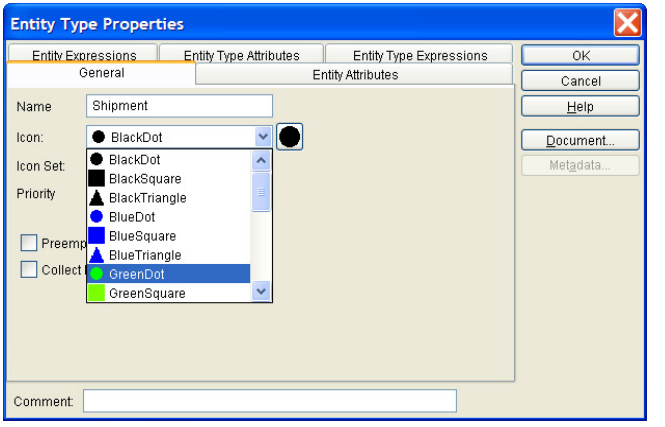
- **Metadata...** opens a dialog for metadata entry. See the *SIMPROCESS Metadata Manual* for information on using metadata in a SIMPROCESS model.

- **Comment** is used to enter brief text describing the purpose of the Entity.

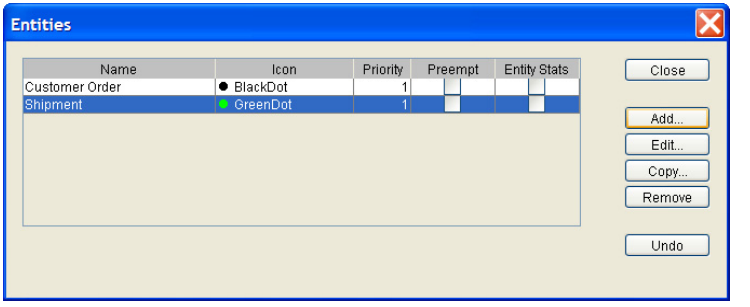
4. Click on **OK** when data entry is completed. The defined Entity is added to the table in the **Entities** dialog.



5. Add another Entity and name it **Shipment**. Click on the pull-down arrow next to the **Icon** field to get a list of Entity icons.



The list may be a lot longer than it first appears. Click near the top of the scroll bar to see more list items. Select *GreenDot*. Then click on **OK**. The icon selected will appear on the button next to the icon list. Clicking the button will bring a dialog that shows the default size of the icon.



Note that the basic properties of Entities added to the model can be edited directly from the table. However, changes made in the table are direct changes to the properties of the Entity and cannot be canceled. Also, the table can be sorted by a particular column by clicking on the column header. Holding the **Shift** key while clicking on a column header causes the table to sort in the reverse order.

Copy the properties of an existing Entity (such as the one just defined) by selecting the Entity in the table and click on the **Copy** button. Enter a different Entity **Name** and make any other changes on the **Entity Type Properties** screen, and then click on **OK**.

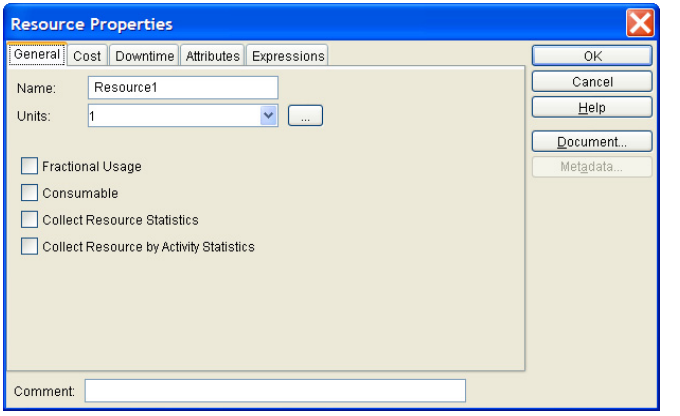
Remove an existing Entity by selecting the Entity and clicking on the **Remove** button. The **Undo** button restores Entity definitions that have been removed. Click on **Close** when Entities are defined.

Defining Resources and Processes

Resources

The next thing to define in the model are the Resources required to process Customer Order Entities. To keep things simple, define just one Resource, the clerks needed to process customer orders.

1. Select **Resources...** from the **Define** pull-down menu.
2. Select **Add** to define a new Resource.



See Chapter 5, “Resource Modeling Constructs,” beginning on page 147 for an explanation of the remaining options and commands, and for more details on defining Resources, including pre-defined Resource types.

Processes

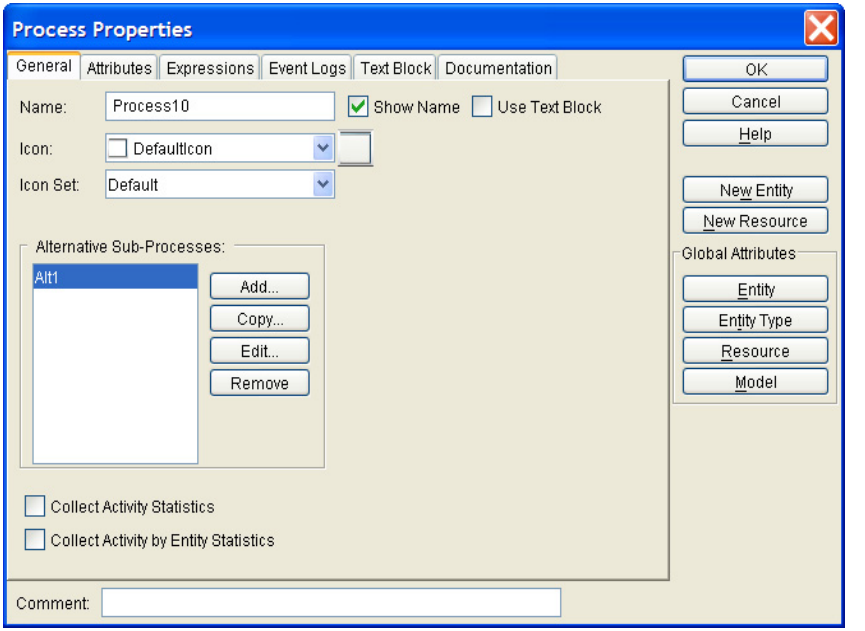
A SIMPROCESS Process defines Processes hierarchically. In this example, we will define a Process that indicates how customer orders are handled

Select the **Process** button from the Layout Toolbar and click on the layout.

Display a dialog for defining the Process. Do this by either:

- Clicking on the **Process** icon to select it, and then pressing **Alt+Enter**

- Selecting the **Process** icon, and then selecting **Edit** from the menu bar, followed by **Properties...**



Alternative Sub-Processes

A Process may consist of a set of Alternative sub-processes. Each sub-process can represent an alternative implementation of the Process. This allows the creation of many variations of a Process and keeps them organized in one place.

Only one sub-process can be active at any point in time. An experiment may be run with Alternative sub-process 1 active to measure the overall performance of the model. Alternative sub-process 2 can then be run and results compared.

SIMPROCESS defines a single default sub-process when a Process is created. Renaming the sub-process to something more meaningful for the model is accomplished by:

1. Selecting it from the **Alternative Sub-Processes** list on the **Process** dialog.
2. Clicking **Edit** to modify the sub-process definition.
3. Highlighting the existing name and typing over it. For this example, call the sub-process **Main**.
4. Click on **OK**.

The new name appears in the **Alternative Sub-Processes** list and becomes the sub-process.

More sub-processes may be added to the Process by clicking on **Add** and naming the new sub-process. Activate a different sub-process by selecting it from the **Alternative Sub-processes** list.

Sub-processes may be deleted with the **Remove** command button and copied using the **Copy** button.

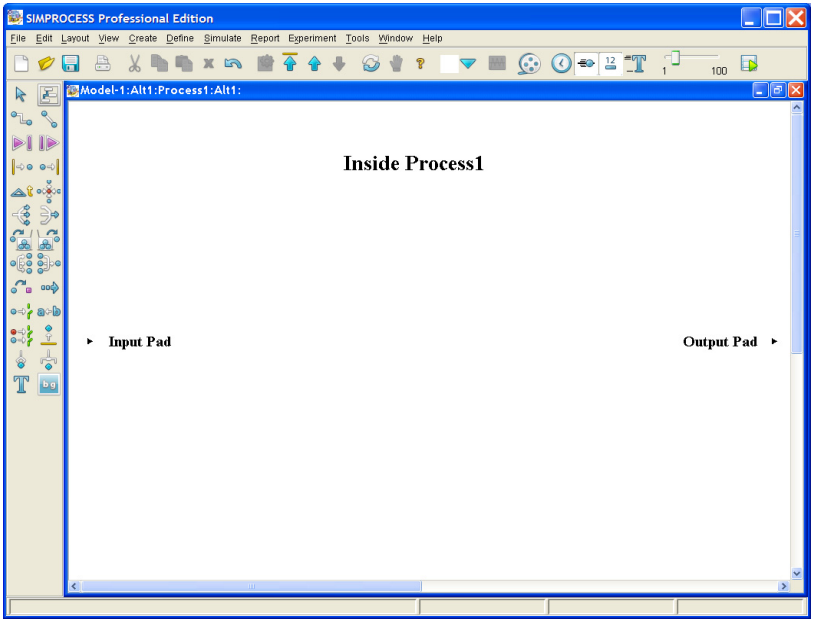
Click on **OK** when the **Process** is defined.

Adding Detail to a Process

Once a Process is defined, define the Activities and Processes that make up the Process.

Right-click on the **Process** icon and choose **Descend** to open the layout of the currently active sub-process

A blank layout is shown, except for two Pads: an input Pad on the left and an output Pad on the right. If the output Pad is not visible, scroll to the right.



These Pads connect any Processes and Activities at this level of the sub-process to the Activities and Processes at the next higher level. Once the input and output Pad are connected by Connectors, Entities flow from level to level.

Activities (and Processes) may be added within the sub-process to detail the tasks being performed.

NOTE: Make sure the Input and Output Pads are connected on all sub-processes. If this is not done, Entities will have no path to follow across the Process. Entities entering the Process will never emerge again.

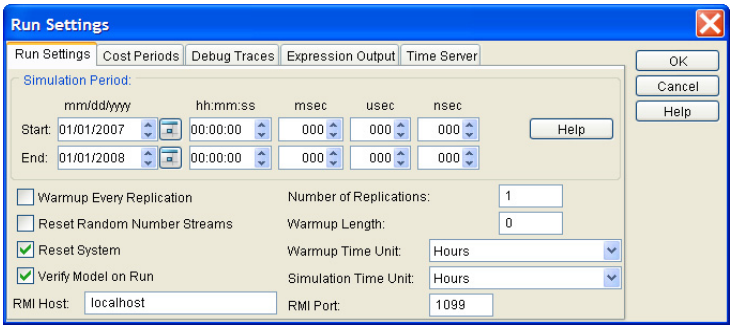
Simulation Setup

Two steps are needed before running a simulation:

- Set the run time parameters for the simulation. This could include start and end dates or number of times to repeat the simulation.
- Set animation parameters.

Run Settings

Select **Simulate** from the SIMPROCESS menu and then click on **Run Settings…** to set run time options.



Setting the Start and End Dates

The values chosen for the **Start** and **End** fields determine how long the simulation runs, in calendar time. A simulated month of processing can be specified as:

Start: 1/1/2007 00:00:00:000:000:000

End: 2/1/2007 00:00:00:000:000:000

This indicates a starting date of January 1, 2007, at midnight, and an end date of February 1, 2007, at midnight. The simulation terminates as soon as the clock strikes midnight at the end of January 31. The calendar button next to each date field can be used to set the date for that field. The calendar button causes a graphical calendar to appear. The date selected on the graphical calendar populates the appropriate date field.

A time must be entered or the hours, minutes, seconds, nanoseconds, microseconds, and

milliseconds fields default to zero.

NOTE

> Remember that **Start** and **End** dates for objects in the model, must be coordinated those with the simulation run dates.
>
> For example, a Generate Activity with **Start** and **End** dates that fall outside of the simulation **Start** and **End** dates will not generate Entities during the simulation. Or, a **Resource Downtime** with **Start** and **End** dates outside of the simulation **Start** and **End** dates will not be applied.

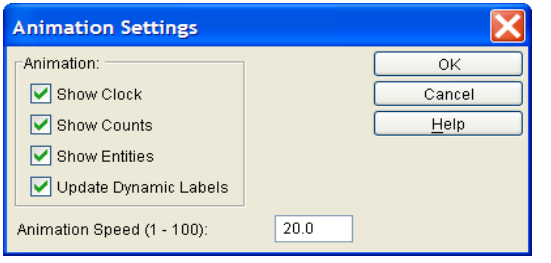
Run Dates and the Real Calendar

Both entity generation schedules and resource downtime schedules can be based on a day of the week. SIMPROCESS calculates the day of the week, as well as the month, year, and time of day, at any moment in a simulation. It maps the simulation dates to the real calendar. For example, in 2007 the year begins on a Monday.

Setting the Simulation Time Unit

SIMPROCESS allows the **Simulation Time Unit** to be set, which is the time unit of the simulation clock. The simulation clock must maintain a constant time unit. The default is *Hours*. Even though each individual time unit can be different, those times are converted to the time unit of the simulation clock. Also, this is important for reducing rounding errors. If the primary delays in the model are in seconds or less, the time unit of the simulation clock should be set to *Seconds* or less. Converting a delay in nanoseconds (or even seconds) to hours could result in rounding errors, whereas converting a delay in nanoseconds to seconds or less would not.

Animation Settings



Show Clock turns the simulation time clock on or off while the simulation is running.

Show Counts. If **Show Counts** is turned on, each Activity or Process will display a number above its icon.

- Generate Activities show the number of Entities generated.
- Dispose Activities show how many Entities have been disposed.
- All other Activities and Processes show how many entities are in that Process or Activity.

Show Entities turns the display of Entities on or off during the animation. Showing Entities assists with visualizing the workflow.

Update Dynamic Labels turns the display of dynamic labels on or off during the animation.

Animation Speed. Changes the **Animation Speed** during the simulation. The fastest value is 100, and the default is 20. A smaller value is better while debugging the model.

Running a Simulation

Start the simulation running, either by clicking the run icon on the tool bar, or selecting **Simulate** from the SIMPROCESS menu bar, followed by **Run**.

Before starting the simulation, SIMPROCESS does two things:

1. Prompts for saving the latest changes to the model
2. Checks the model for errors.

SIMPROCESS issues informational messages and aborts the simulation if errors are found.

Choose **Verify Model** from the **Simulate** menu before running to check the model for errors before running a simulation.

Running a Simulation with Model Parameters

If the model has User-defined Attributes which were selected as Model Parameters, when the simulation run is started, SIMPROCESS will prompt for initial values for those Model Parameters.

The Model Parameters are displayed in a table. The column under **Parameter** gives the name of the User-defined Attribute. The **Value** column shows the value the attribute will have at the start of the simulation run.

To change the value of a Model Parameter, select it in the table. The Description of the selected parameter will be displayed below the table along with its default value and the mode of its value (integer, real, etc.)

The next step is to enter the desired value of the Model Parameter in the **Value** field. If **Reset** is pressed, the selected Model Parameter will return to its default value. The **Reset All** button, under the **Help** button, will set the value of all the Model Parameters back to their defaults.

Creating Model Parameters from User-defined Attributes is covered in Chapter 10, “Customizing a Model with Attributes and Expressions,” beginning on page 237.

Model Parameters can be changed during a simulation run by selecting **Change Model Parameters** from the **Simulate** menu.

Allowable Actions During a Simulation

While a simulation is running, a Process can be descended into to view Entity movement within the Process hierarchy. Descending into a Process is done by using **Descend** on the **View** menu, clicking

the down arrow on the tool bar, right clicking on a Process and choosing **Descend**, or by double-clicking on a Process.

Choose **Ascend** on the **View** menu to ascend to a higher level of the model hierarchy. Click the up arrow on the tool bar, right click on blank area and choose **Ascend**, or double-click on any blank area of the model layout. Choose **Go To Top** instead of **Ascend** to ascend to the top level of a model.

The **Simulate** option on the menu bar causes the following options to occur:

- Pause the simulation
- Resume simulation after a pause
- Stop the simulation before its scheduled end
- Click on **Animation Settings** to change animation options. The simulation pauses while this is being done. Changing the animation options using the tool bar does not pause the simulation.

Double click on an **Activity** icon to bring up its properties dialog. However, any changes made will not be reflected in the running simulation.

Animation can be recorded for playback after the simulation ends. (See “Post Simulation Animation” on page 172.)

Standard Report

After the simulation run has completed, the Standard Report may be displayed to view output statistics for the model. From the **Report** menu bar, choose **Display Standard Report**.

This will open the **Display Standard Report** dialog. In the **Report Replications** list box (if the model ran for multiple replications), select an individual Replication, the Average of All Replications run, or the Sum of All Replications run. Typically, the report of interest will be the Average of All Replications report. **Calculate Confidence Intervals** is activated if the Average of All Replications report is selected, which allows selection of 90%, 95%, or 99% confidence intervals for each performance measure. Select to view the Standard Report with a **Text Editor** (Wordpad by default) or with a **Spread Sheet** and press the **Display Report** button to open the report.

See Chapter 8, “Output Reports,” beginning on page 185 for more detail on the Standard Report.

CHAPTER 3

Statistical Modeling Constructs

SIMPROCESS allows the analyzing of processes using discrete event simulation. This means that SIMPROCESS models systems by taking the processes that happen in the real world and breaking them down into the key events that occur. Parts move to a station in a factory, are processed, and then move to the next station. If one part goes into a station and one part comes out, then the most important aspect of modeling the station would be to capture the processing time (which, in the real world, will vary due to any number of factors) by a statistical distribution.

A statistical distribution is used to give the model the randomness that always occurs in the real world. Of course, if things in the real world never varied, simulation would not be needed! Mean-value analysis of your system would suffice. Mean-value analysis is a simple way of predicting system performance by looking only at average rates. Unfortunately, the real world almost never matches the performance predicted by mean-value analysis, because statistical fluctuations almost always need to be taken into account.

Expertise in statistics or modeling is not needed to use SIMPROCESS, though; just having some idea of how things vary is enough. If data shows it usually only takes 5 minutes for a clerk to process some paperwork, but it can take as long as 15, that is the beginning of a statistical model of that clerk. Exact answers are not necessary, just general behavior. Introducing a small amount of randomness through simulation can be all that is needed to transform a simplistic mean-value analysis into a realistic model.

SIMPROCESS provides a visual flow through the system, in addition to being able to model

processes' statistical nature. It is very difficult to know how people, machinery, deliveries, and resources are going to interact in a proposed system. SIMPROCESS shows how these interactions might occur while still in the planning stage. Animation provides valuable insight into how things work and how they could work.

Random Number Generation and Standard Distributions

Random Number Generation

SIMPROCESS contains 215 random number streams, each having a different random number seed. You can view the seeds available from **Seeds** on the **View** menu.

The purpose of using different random number streams in the model is to control variance. This is an advanced topic well beyond the scope of this manual. Please refer to texts on statistics and randomness, including *Simulation Modeling and Analysis* by Law and Kelton (McGraw-Hill).

Standard Distributions

SIMPROCESS includes many standard probability distributions built in, and you can also create empirical distributions from your own data. The following paragraphs discuss selecting distributions and provide brief descriptions of some of the most common standard distributions.

Choosing the Right Distribution for Your Data

It is not always clear which of the standard distributions should be used. Fortunately, simulation results are usually not highly dependent on the choice of distributions. A distribution with approximately the right shape should be adequate.

ExpertFit (**Tools** menu) uses sophisticated statistical tests to determine the best fit distribution to a set of experimental data. Additional information on ExpertFit is covered in the ExpertFit documentation, which is located on the **Help** menu in ExpertFit.

ModelFit, which is used with the Auto Fits feature, also fits distributions to empirical data. (See “Auto Fits Distributions” on page 101.)

Common Distributions

Poisson: Used to model arrivals where the quantity within a time frame is known. Parameter: Mean.

Exponential: Used to model the time between arrivals. Parameter: Mean.

Normal: Bell-shaped curve; avoid when mean is near zero. Also, the normal distribution is not usually a good distribution for service times since service times are usually skewed to the right. Parameters: Mean, Standard Deviation

Lognormal: Can be good distribution for data that is skewed. Parameters: Mean, Standard Deviation

Triangular: Useful distribution for data that has the least amount of time, the most likely time, and the most amount of time it takes to perform a task. Parameters: Minimum, Mode, Maximum

A complete listing of the statistical distributions available in SIMPROCESS is available in Appendix D. See “Statistical Distributions” on page 477.

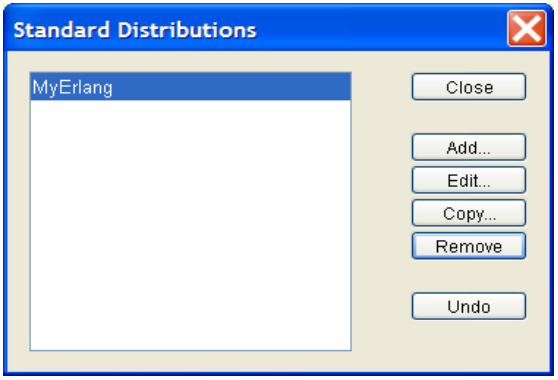
User Defined Distributions

There are three methods for creating **User Defined Distributions** listed on the **Define** pull-down menu. The first, **Standard…**, customizes an existing SIMPROCESS distribution. The second, **Tabular…**, creates a statistical distribution from discrete data points using a table format. **Auto Fits...** automatically fits a distribution from sample data at the beginning of a simulation. The sample data can be in an ASCII file, spreadsheet, or database. ModelFit is used to perform the distribution fitting. (See **Help/About SIMPROCESS...** for information on ModelFit.) Note that the Auto Fit feature is licensed separately from SIMPROCESS.

These **User Defined Distributions** can be used anywhere in the model where a statistical distribution is specified.

Standard Distributions

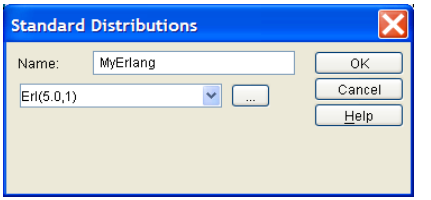
1. Using the **Define Distributions** pull-down menu, select **Standard....** Use this dialog to **Add, Edit, Copy**, or **Remove** User Defined Distributions found in the list box. **Undo** retrieves a distribution that has been removed.



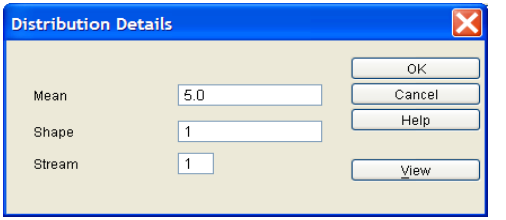
2. Choosing the **Add**, **Edit**, or **Copy** button brings up another dialog as shown below, where you type in the **Name** and distribution:

   Name is any unique non-blank user distribution name.

   Select a distribution for modification.



3. Using the distribution text box, either change the parameters of the distribution within the parentheses or select the details button (three dots). This button opens a dialog containing the parameter descriptions, e.g., Erlang parameters.



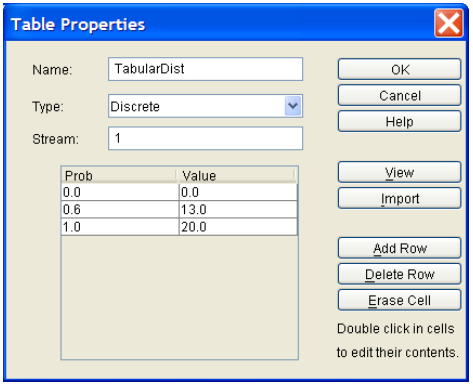
4. To see the PDF (Probability Distribution Function) and CDF (Cumulative Distribution Function) plotted, choose the **View** button from the dialog shown in Step 3. The PDF is labeled on the left y-axis, the CDF on the right y-axis.
5. The graph can be saved to a file. To continue, select **Close** from the graph's **File** pull-down menu.
6. Once the data is entered, choose **OK,** and the defined User Distribution is added to the list box. This User Defined Distribution can now be used anywhere in the model where a statistical distribution is specified.
7. To copy an existing User Distribution, select the distribution, choose the **Copy** button, and you can enter another **Name** for the distribution.
8. To remove an existing User Distribution, select the distribution, and choose the **Remove** button.
9. Choose the **Close** button to finish with User Distributions.

Tabular Distributions

Tabular Distributions creates a statistical distribution from a table of discrete data points.

1. Select **Tabular...** from the **Define Distributions** pull-down menu. Use this dialog box to **Add, Edit, Copy**, or **Remove** Tabular Distributions in the list box.

2. Choosing the **Add**, **Edit**, or **Copy** button brings up another dialog as shown below:



3. Type in the **Name** any unique non-blank User Distribution name.
4. **Type** is selected from the list box. Choose either a **Discrete** or **Continuous** probability distribution function. If **Discrete** is chosen, only the exact values indicated in the right column will be chosen when the distribution is sampled. If **Continuous** is chosen, SIMPROCESS will interpolate from the specified **Values** and the probabilities associated with them.
5. To update the table, point and click on the cell you wish to modify. Type the number in the table cell directly.

   Rows may be added and deleted by clicking on a cell and then choosing the appropriate button on the right. The row will be added above the one selected. The **Erase Cell** button causes the entry in the selected cell to be erased.

   A table may also be populated by importing data from a text file using the **Import** button.

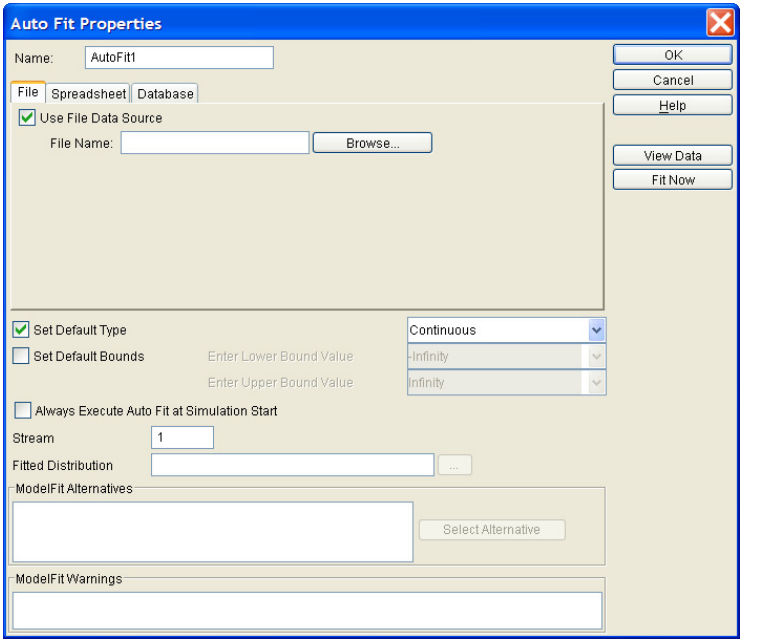
   Choose the **View** button to see the PDF and CDF plotted. The graph can be saved to a file. Select **Close** from the graph's **File** pull-down menu to continue.
6. Once the data is entered, choose **OK,** and the Tabular Distribution is added to the list box. This Tabular Distribution can now be used anywhere in the model where a statistical distribution is specified.
7. To copy an existing Tabular Distribution, select the distribution, choose the **Copy** button, and enter another **Name** for the distribution.
8. To remove an existing Tabular Distribution, select the distribution, and choose the **Remove** button.
9. Choose the **Close** button when the Tabular Distributions are complete.

Auto Fits Distributions

Creating an Auto Fit Distribution

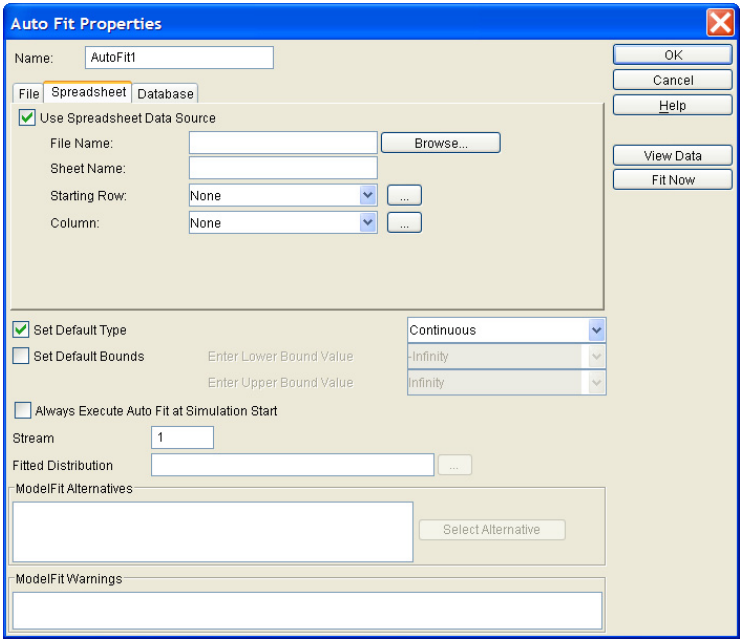
Auto Fits Distributions creates a statistical distribution from external sample data using ModelFit.

1. Select **Auto Fits...** from the **Define Distributions** pull-down menu. Use this dialog box to **Add, Edit, Copy**, or **Remove** Auto Fits Distributions in the list box.
2. Choosing the **Add**, **Edit**, or **Copy** button brings up another dialog as shown below:



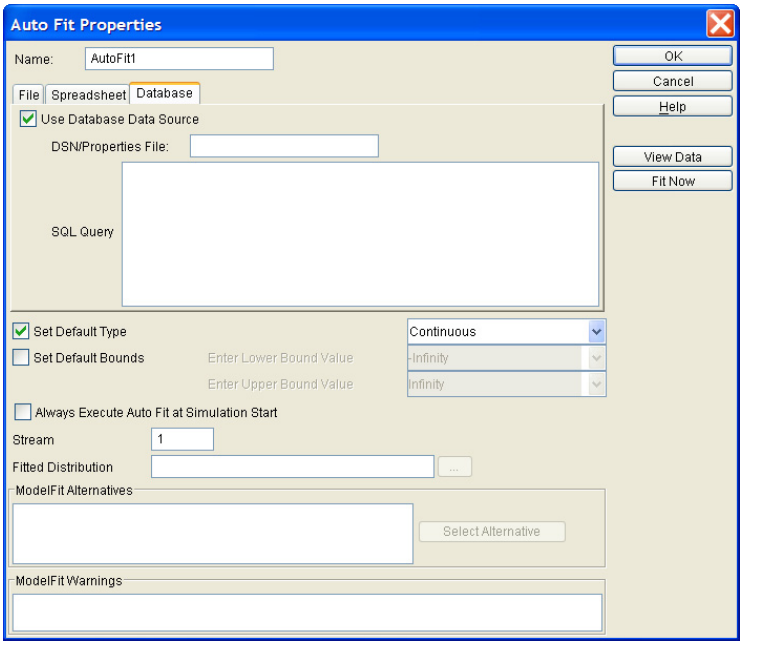
3. Type in the **Name** any unique non-blank User Distribution name.
4. There are three tabs (**File**, **Spreadsheet**, and **Database**) that are used to specify the source of the sample data. One or more types of data source can be used. However, only one list of sample data will be fitted. Thus, if more than one data source is used, the data from all selected sources are combined into one list for distribution fitting.
5. The **File** tab is used to specify an ASCII file as the data source. **Use File Data Source** must be selected to use this type of data source. The **Browse** button can be used to locate the file. It is recommended that the file be located in the model's directory. Note that the file must contain a single column of numbers with no header and no non-numeric values.

6. The **Spreadsheet** tab specifies a spreadsheet as a data source. The Spreadsheet can be a Workbook file or an XML Spreadsheet. Once **Use Spreadsheet Data Source** has been selected, four fields are required: **File Name**, **Sheet Name**, **Starting Row**, and **Column**. The **Browse** button can be used to locate the spreadsheet file. Again, it is recommended that the file be in the model's directory. Enter the name of the worksheet in the **Sheet Name** field. **Starting Row** should have the row number (rows start with 1) that contains the first value. **Column** should have the column number (column A would be column number 1) of the sample data. The data must be in a single column with no empty cells. The data is read beginning at the **Starting Row** and continues until an empty cell is reached. Both **Starting Row** and **Column** are distribution list fields. Thus, the **Starting Row** and **Column** can be parameterized (such as `Evl(Model.StartingRow)` or `Evl(Model.Column)` where Model.StartingRow and Model.Column are Model Attributes designated as Model Parameters).

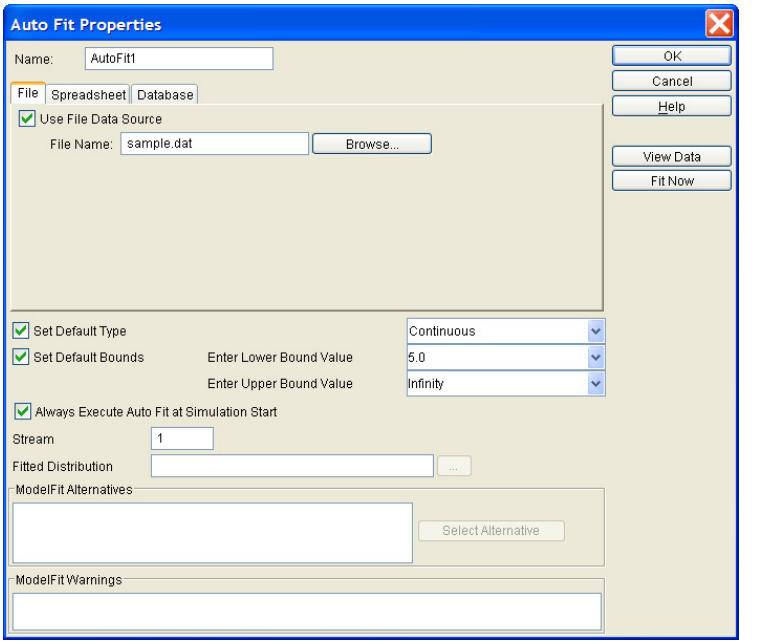


7. The **Database** tab is used to specify an SQL database as the data source. **Use Database Data Source** must be selected to use this type of data source. Two items are required: **DSN/Properties File** and **SQL Query**. **DSN/Properties File** must contain the database location/connection information. **DSN** stands for Data Source Name and is the **DSN** established in the Windows ODBC Control Panel. (See "Setting Up Database Using Windows and Open Database Connectivity (ODBC)" on page 296 for more information on DSNs.) **Properties File** is the name of the properties file that contains the JDBC url and driver information and, if necessary, username and password. A **Properties File** must be used on a non-Windows system and must be located in the model's directory. (See "OpenDatabase" on page 298 for more information on Properties Files.) **SQL Query**

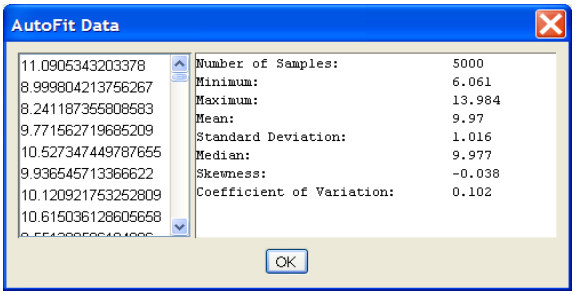
must contain the query that returns the sample data. The query can be parameterized by using model attributes. For example, `"Select TIME_VALUE From TimeTable"` can be changed to `"Select Model.TableColumn From TimeTable"`. In this example, Model.TableColumn is a STRING Model Attribute that contains the name of the column to read. Note that if the query returns multiple columns, only the first column will be read for sample data.



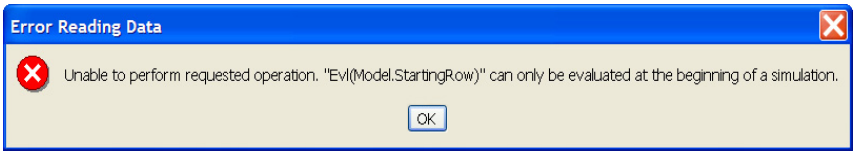
8. Below the data source section of the dialog are two checkboxes: **Set Default Type** and **Set Default Bounds**. These checkboxes allow "hints" about the sample data to be passed to ModelFit. Information about the sample data can be useful in obtaining a proper distribution fit. If **Set Default Type** is selected (default), then either **Continuous** (default) or **Discrete** can be selected. For example, sample data representing time between arrivals is usually **Continuous**, whereas sample data representing number of arrivals is usually **Discrete**. If **Set Default Bounds** is selected, then the lower and upper bounds can be set and passed to ModelFit. **Enter Lower Bound Value** contains two selections: **-Infinity** and **0.0**. **Enter Upper Bound Value** contains one selection: **Infinity**. Other numeric values can be used as bounds by typing the values in the appropriate field. For instance, if the sample data represents task times, then there could be a minimum and/or maximum time to perform the task. Thus, the fitted distribution should reflect those times. In the example below, 5 is the lowest possible value that the fitted distribution should return. This means the task represented by the sample data has a minimum completion time of 5 (minutes, hours, etc.). Note that if neither checkbox is selected, then no information about the sample data is passed to ModelFit.



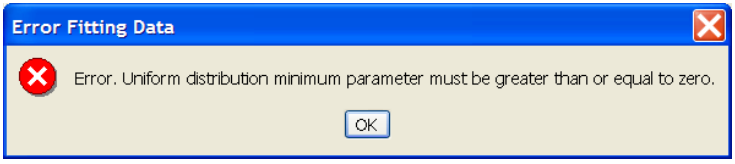
9. When selected, **Always Execute Auto Fit at Simulation Start**, causes the data sources to be read and the distribution to be fitted every time the model is run. Note that fitting will also occur at the beginning of a simulation if **Always Execute Auto Fit at Simulation Start** is not selected and the **Fitted Distribution** field is empty (**Fit Now** has not been executed). An error will occur at simulation start if distribution fitting is attempted, and the Auto Fit license has not been activated.
10. **Stream** contains the random number stream (1 - 215) to use when drawing random samples from the **Fitted Distribution**.
11. The **View Data** button reads the data sources and displays a list of the sample data along with summary statistics. The summary statistics include Number of Samples, Minimum, Maximum, Mean, Standard Deviation, Median, Skewness, and Coefficient of Variation.



Note that if the **Spreadsheet** data source **Starting Row** or **Column** or **Database** data source **SQL Query** are parameterized, the **View Data** button will not return data. A parameterized **Spreadsheet** or **Database** data source can only be read at the beginning of a simulation. **View Data** includes data validation so it can be used to verify the data before a distribution fit.

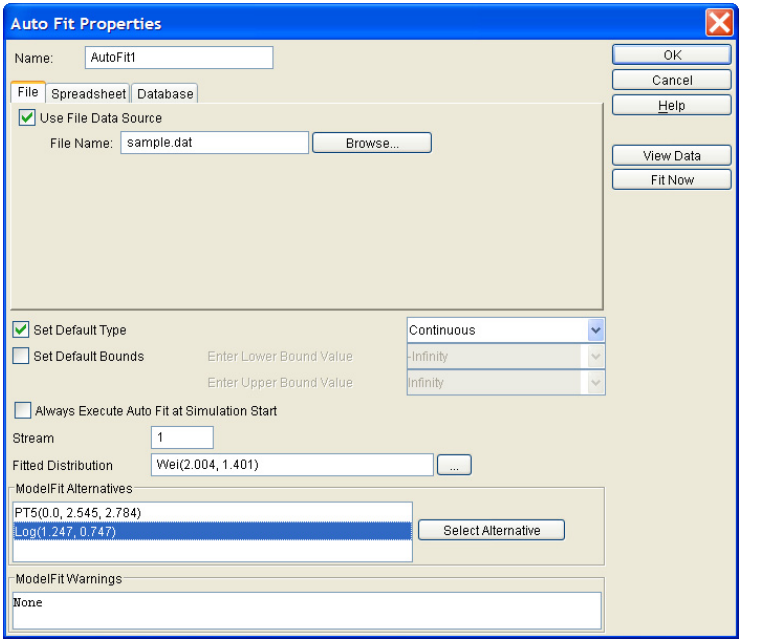


12. The **Fit Now** button reads the data sources and calls ModelFit to perform the distribution fitting. If a good fit is obtained, the **Fitted Distribution** field displays the results. Note that **Fit Now** will not work if either the **Spreadsheet** or **Database** data sources are parameterized (see above). **Fit Now** includes data and distribution validation so it can be used to verify the data and distribution fit before a simulation run. The example error below shows that ModelFit created a Uniform distribution with a negative lower bound. A negative lower bound is not allowed. (See "Statistical Distributions" on page 477 for information on distribution requirements.) Also, an error will occur if the **Fit Now** button is clicked and the Auto Fit license has not been activated.

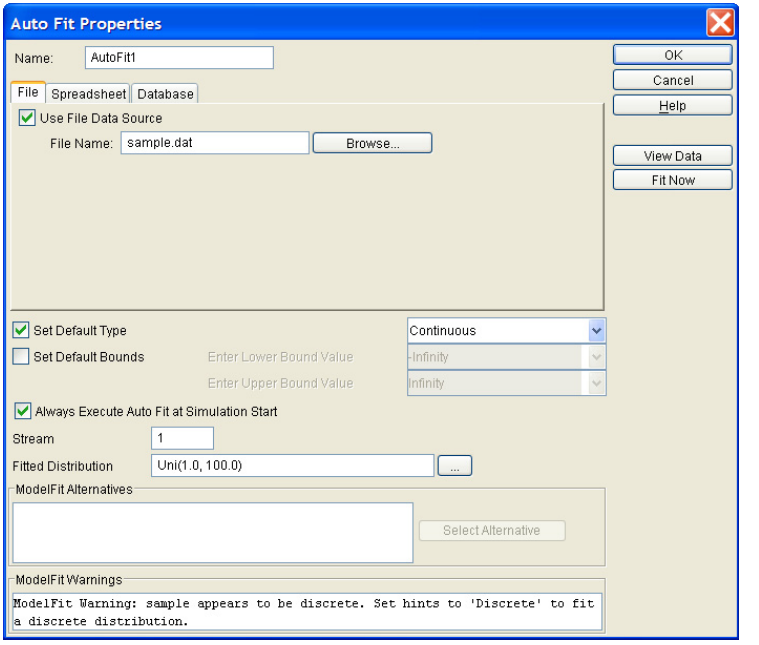


13. The **Fitted Distribution** field contains the results of an Auto Fit. The contents of the field can be selected and copied, but any changes to the field will not be saved. The details button to the right of the Fitted Distribution field can be used to view the individual parameters and view a plot of the distribution. Any changes made to the distribution parameters on the detail dialog will not be saved.
14. **ModelFit Alternatives** contains alternative distribution fits for the sample data. An empty list means that ModelFit determined that there were no acceptable alternatives. To use an alternative distribution, either select the distribution then click the **Select Alternative** button or double click the desired alternative. The primary distribution will be placed into the list of alternatives, and the selected alternative will be placed into the **Fitted Distribution** field. Note that **ModelFit Alternatives** are only applicable when using the **Fit Now** button. It is not possible to select an alternative when Auto Fit is run at simulation start. The primary distribution will always be used when Auto Fit is run at the beginning of a simulation. (When running Auto Fit at simulation start,

alternatives generated by ModelFit are written to the `simprocess.log` file.) To use an alternative as the primary distribution, **Always Execute Auto Fit at Simulation Start** must not be selected.



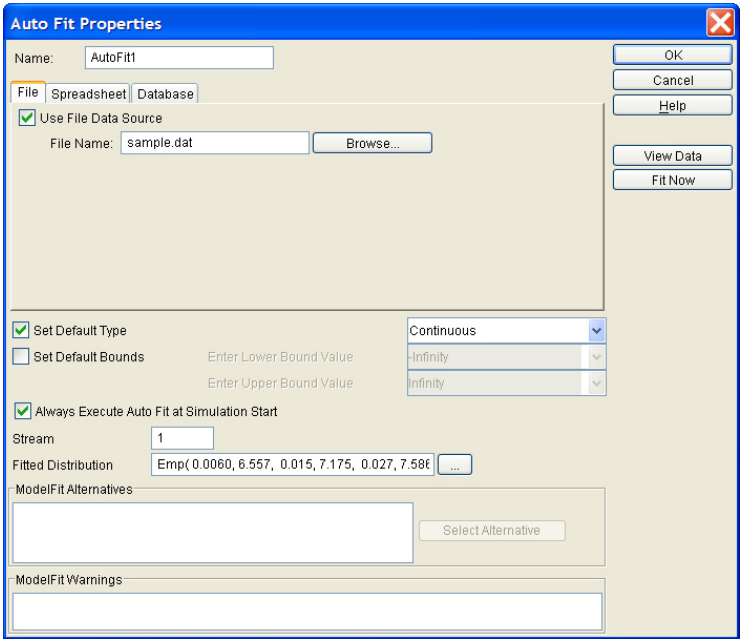
15. **ModelFit Warnings** contains warning messages from ModelFit concerning the **Fitted Distribution**. These warnings are only displayed here when the **Fit Now** button is used. The warnings are written to the `simprocess.log` file (`SPSYSTEM` directory) when fitting occurs at simulation start. **None** is displayed if there are no warnings. The text of ModelFit Warnings can be selected and copied using the platform specific keyboard shortcuts.



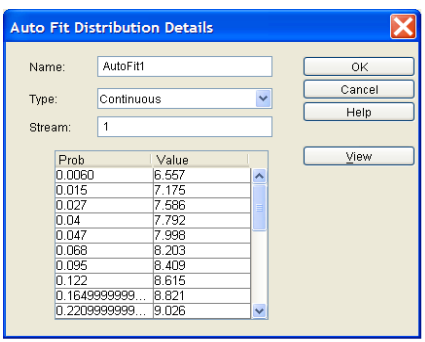
Empirical Distributions

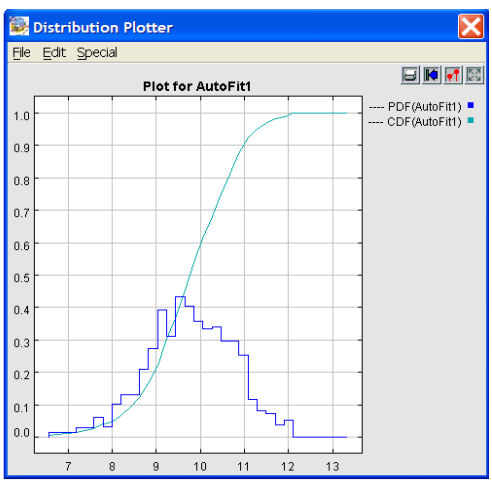
Sometimes ModelFit cannot fit the sample data to one of the SIMPROCESS distributions. This could be due to the sample data representing a distribution that SIMPROCESS does not support, an insufficient sample size, or both. When this happens, ModelFit returns an empirical distribution. The distribution defaults to **Continuous** unless **Discrete** is selected in **Set Default Type**.

An empirical distribution is a histogram based distribution and follows the format of the SIMPROCESS Tabular distribution (page 99). The distribution type displayed in the **Fitted Distribution** field will be `Emp` followed by pairs of cumulative probability and value. The pairs are just comma separated values. In the example below, the first two pairs of cumulative probability and value are (0.0060, 6.557) and (0.015, 7.715).

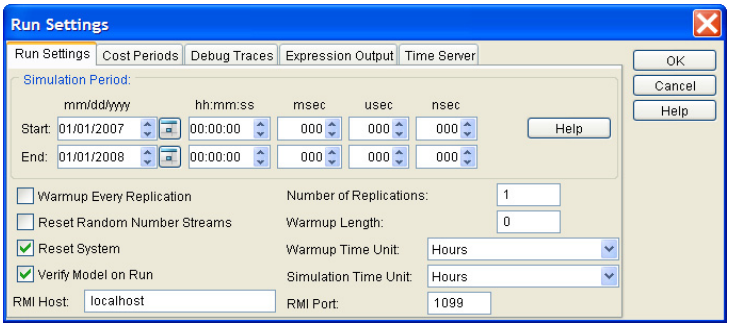


A table of the values can be displayed by selecting the details button next to the **Fitted Distribution** field. By selecting the **View** button, the dialog allows viewing a **Continuous** or **Discrete** (based on selected **Type**) plot of the empirical distribution. Note that changes to the **Name**, **Type**, or **Stream** are not saved.





Run Settings



Run Settings

Simulation Period

The **Simulation Period** determines how long the simulation will run. It is given in calendar and time format. Choose an appropriate time span to see all aspects of the system.

Warmup Every Replication

When selected and the values for both the **Number of Replications** and **Warmup Length** are greater than 0, SIMPROCESS will start collecting statistics after the **Warmup Length** has expired for each replication.

Warmup Length

If a **Warmup Length** is entered SIMPROCESS will start the collection of statistics for the model run, after the end of the **Warmup Length**. This gathers information on your system after it has reached "Steady State."

Warmup Time Unit

The **Warmup Time Unit** specifies the time unit for the **Warmup Length**. It defaults to Hours.

Simulation Time Unit

The **Simulation Time Unit** specifies the time unit for the simulation clock. It defaults to Hours.

Reset System

Resets the system to the initial conditions before each replication.

Verify Model on Run

Turns the automatic model verification on or off at the beginning of a simulation. The verification process checks to make sure all pads are connected.

Number of Replications

When the model contains randomness (represented by statistical distributions) the model should be run for multiple replications. This averages the results and gives a more accurate picture of "most likely" outcome of the scenario being modeled.

Reports are gathered for each replication and the Sum and Average of all runs.

Reset Random Number Streams

This option resets the **Random Number Stream** before starting each new replication. Typically, this should not be selected. In general terms, the reason for running the model for multiple replications is to test how randomness affects the system. Turning this option on negates that test.

RMI Host

This indicates the host on which SPServer will be located if the model has an External schedule defined. Defaults to "localhost." (See "Adding an External Schedule" on page 335.)

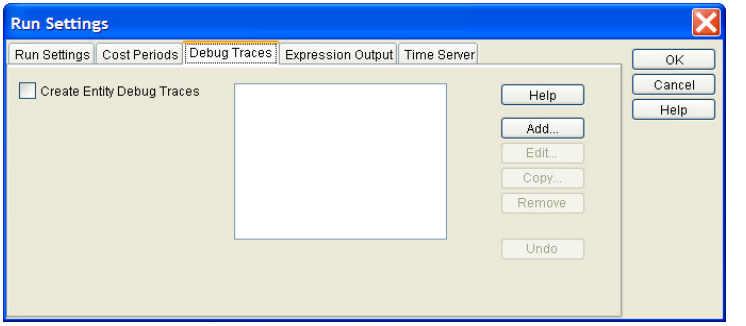
RMI Port

This indicates the TCP port to use on the **RMI Host**. Defaults to 1099. (See "Adding an External Schedule" on page 335.

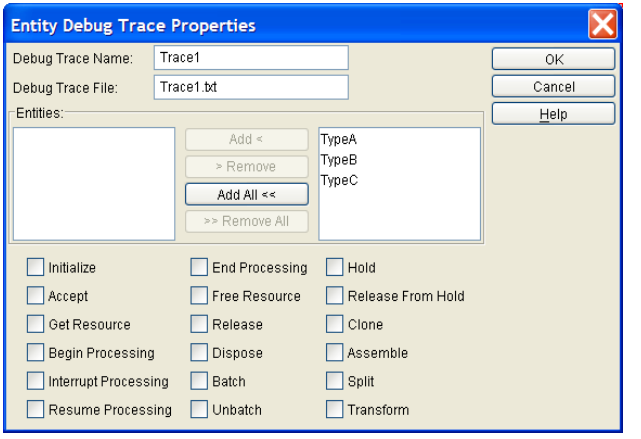
Cost Periods

This tab sets the frequency over which the ABC Reports will be collected. The name of the currency that the ABC Reports will use can also be set. (See "Setting Up Cost Periods" on page 179.)

Debug Traces



This tab turns on/off debug tracing and defines debug traces. If checked, **Create Entity Debug Traces** causes the creation of the debug traces defined in the box to the right. If no debug traces are defined, no debug traces are created during the simulation run. Click the **Add...** button to define a debug trace. This brings up a dialog for defining the debug trace.



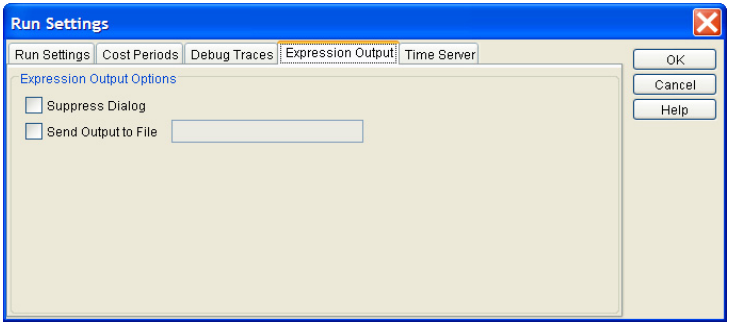
Debug Trace Name is the name of the trace that will appear in the list of traces. **Debug Trace File** is the name of the debug trace file to be created. If no path is included, the file will be created in the directory of the model. Select the **Entities** to be included in the trace. Entity types to be included should be moved from the list of entities on the left to the list of entities on the right. The checkboxes at the bottom are the Entity actions that can be included in the trace. Note that the **Clone**, **Assemble**, **Split**, and **Transform** actions apply to the Entity that initiates the action, not the Entity or Entities that result from the action.

Each debug trace file is a tab delimited file. The replication is added to the file (Replication 1, Replication 2, etc.) and then a header line consisting of Action, Activity, Entity, SequenceNum, and SimTime. Each action added to the file consists of the action name (Initialize, Accept, etc.), the name

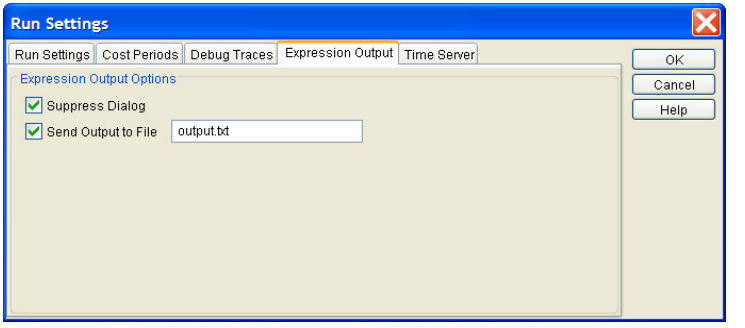
of the activity, the name of the entity, the sequence number of the entity, and the simulation time.

Expression Output

The SIMPROCESS Expression Language has a statement called `OUTPUT`. This statement displays information in the SIMPROCESS Expression Output Dialog. (See "Expression Language Statements" on page 257.) `OUTPUT` is especially useful for debugging. The **Expression Output** tab offers options for the `OUTPUT` statement. (Note that these options also apply to the `ShowSystemAttributes` and `ShowUserAttributes` System Methods. See "SIMPROCESS System Methods" on page 521.)



There are two options: **Suppress Dialog** and **Send Output to File**. By default, both options are not selected. If selected, the **Suppress Dialog** option prohibits the SIMPROCESS Expression Output Dialog from displaying during a simulation. (Suppressing the dialog causes the simulation to run faster.) If **Send Output to File** is selected, the `OUTPUT` statements are written to the file entered in the adjoining text field. Since the file defaults to the model's directory, the file name entered must not contain a path.



These options apply when running simulations using the Experiment Manager (see "Experiment Manager" on page 387). However, **Suppress Dialog** has no affect on the Experiment Manager Status

Messages dialog.

SIMPROCESS models can be run without the SIMPROCESS Graphical User Interface (see "Running Models Without GUI" on page 599). The optimization tool OptQuest (see "OptQuest for SIMPROCESS" on page 401) and the SIMPROCESS Dispatcher do this. (The SIMPROCESS Dispatcher is an optional feature that allows SIMPROCESS to be used with a Web service. If the SIMPROCESS Dispatcher was installed, see `SIMPROCESS Dispatcher.pdf` in the `dispatcher` directory for more information.) If **Suppress Dialog** and **Send Output to File** are not selected, then `OUTPUT` statements are written to the appropriate log file. In most cases, the log file will be `simprocess.log` in the `SPSYSTEM` directory. When using OptQuest, the log file is `optQuest.log` in the `SPSYSTEM` directory. The Dispatcher log file is `Dispatcher.log`. Its location is dependent on where the Web service is located. If either **Suppress Dialog** or **Send Output to File** is selected, then no information is sent to a log file. When **Send Output to File** is selected, the `OUTPUT` statements are written to the designated file.

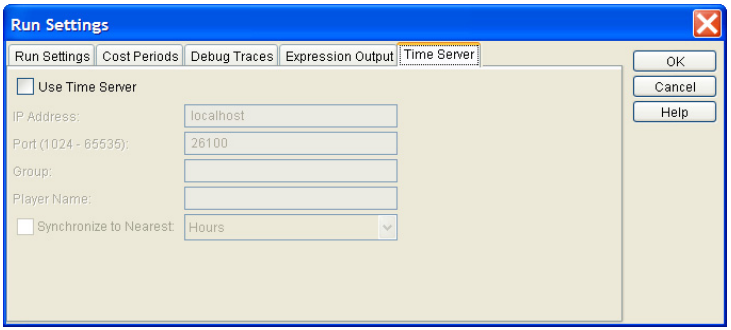
Whether running a model with or without the SIMPROCESS GUI, the file designated in **Send Output to File** will contain output for all replications; however, when the same model is run again, the file will be overwritten. So if a user, the Experiment Manager, OptQuest, or the SIMPROCESS Dispatcher runs the same model multiple times, the file will only contain information from the last run.

Time Server

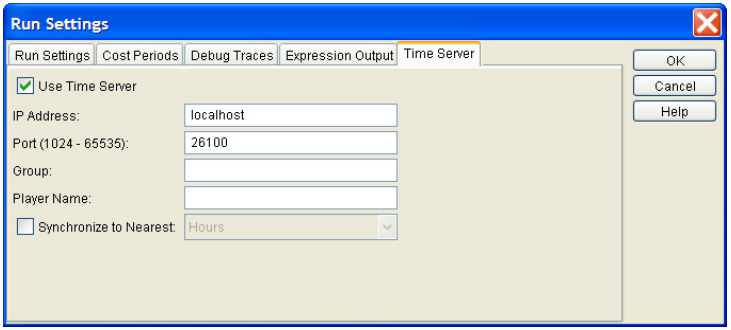
SIMPROCESS models have the ability to let an outside agent manage the advancement of simulation time. The TimeServer is a separate application which can manage simulation time for multiple participants. It can be run on the same machine as SIMPROCESS or on another system. See `SIMPROCESS TimeServer.pdf` in the `timeserver` directory for more information, including how to configure and run the TimeServer application. The `timeserver` directory is in the SIMPROCESS installation directory.

The TimeServer supports one or more groups of players. Each group has a unique name among those handled by a single instance of the TimeServer, and each group manages its own time independently of all other groups. Thus, for a SIMPROCESS model to use the TimeServer, it must join a predefined TimeServer group as a player.

Time Server Settings



The **Use Time Server** option is initially not selected. When selected, **IP Address**, **Port**, **Group**, **Player Name**, and **Synchronize to Nearest** become enabled. Values for **IP Address**, **Port**, **Group**, and **Player Name** are required when using the TimeServer while **Synchronize to Nearest** is optional.



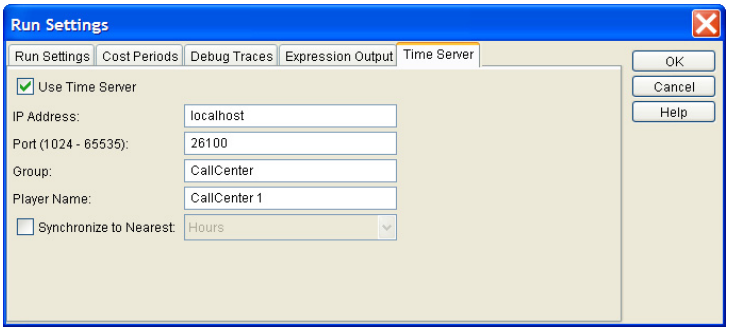
IP Address defaults to `localhost`, which indicates that the TimeServer will be running on the same system as SIMPROCESS. If the TimeServer will be running on a different system, then the IP address or host name of that system should be entered.

Port can be between 1024 and 65535 inclusive and defaults to 26100.

Group is the name of the TimeServer group that this model will join. Groups are defined as part of the TimeServer configuration. See `SIMPROCESS TimeServer.pdf` in the `timeserver` directory for more information.

Player Name is the name by which the simulation will be known to the TimeServer **Group**. This name cannot be duplicated within a **Group**.

In the example below, at the start of the simulation, the model will join the group `CallCenter` as `CallCenter 1`.

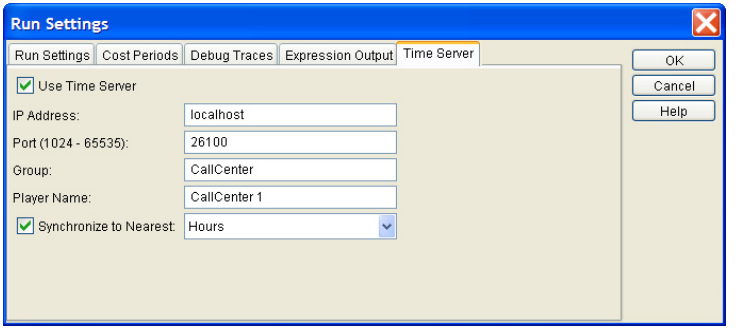


During simulation SIMPROCESS creates events internally, each bearing a time stamp indicating the simulation time when they will be processed. Events are placed into a queue to be processed in the order of their simulation times. A large and complex model will handle a great many such events as it simulates.

When a TimeServer is used to manage simulation time externally, an additional step is introduced into this process. Before any event can be processed, SIMPROCESS must have gained approval from the TimeServer to advance to or beyond that event's time. Therefore, SIMPROCESS must recognize when it has events scheduled to occur later than the most recently approved time and send a request for time advancement to the TimeServer.

When **Synchronize to Nearest** is not selected, this event handling occurs naturally, as dictated by the simulation times of each event and the responses from the TimeServer. This is referred to as *full synchronization*. Events may occur with very small amounts of time between them. Large and complex models can send a significant number of time advancement requests to the TimeServer. Depending on the number of players participating in the simulation group, and the complexity of their respective simulations, this can result in a great deal of time spent simply waiting for time advancement approval and can therefore cause overall simulation performance to suffer.

Selecting **Synchronize to Nearest** can sometimes improve this situation. When selected, it enables the list for selecting an available time unit, which defaults to Hours. (All valid SIMPROCESS time units are available.) When used, SIMPROCESS will round all its requests for time advancement to integer numbers in the selected time unit (this time unit need not match the **Simulation Time Unit**, discussed on page 109, though it should usually not be a smaller unit). This is referred to as *rounded synchronization*.



As an example, assume that the current simulation time is 1.0 Hours and that the next event in the simulation is scheduled to occur at 1.25 Hours. Instead of sending a request for time advancement to 1.25 Hours, a request for 2.0 Hours will be sent. This is because 2 is the smallest integer value greater than 1.25. If the TimeServer approves the request by sending a time advance notification of 2.0 Hours back to the SIMPROCESS model, then simulation events with times less than or equal to 2.0 Hours will not require sending new time advance requests. So if the next three events had times of 1.5, 1.75, and 2.0 Hours, respectively, those events would not cause new time advance requests to be sent to the TimeServer, thus potentially improving performance by reducing the overall number of requests sent to the TimeServer and enabling SIMPROCESS to continue processing events without delay. (If a shorter time were approved instead, SIMPROCESS would process its events up to the newly approved time and submit another rounded time advance request.)

Note that the effectiveness of rounded synchronization will depend in part on the strategies employed by the other players in the group. If the other players are using full synchronization, or are using rounded synchronization with a smaller time unit, there may little or no benefit.

Time Server Errors

Various errors can cause the premature end of the initialization or run of a simulation that is using the TimeServer.

- TimeServer is not running
- TimeServer stops
- Invalid Group
- Group is already full (all players have joined)
- Group is reinitialized
- Duplicate player name
- Communication error
- Another player terminates with an error condition (there is an option to continue in this case)

Time Server Considerations

When another player completes normally before the completion of the SIMPROCESS simulation, the simulation will continue until it is finished. However, if another player terminates for a different reason, SIMPROCESS will ask whether to continue or stop the simulation.

A SIMPROCESS model should not use External schedules along with a TimeServer. This can lead to unpredictable results. See "Adding an External Schedule," beginning on page 335 for more information on External schedules.

It is not strictly necessary for all SIMPROCESS players to use the same **Number of Replications** or to have the same setting for **Reset System** (both discussed on page 110). However, it's strongly suggested that all SIMPROCESS players in a group use the same **Number of Replications** and **Reset System** settings.

CHAPTER 4

Activity Modeling Constructs

The SIMPROCESS Activities that were not covered in Chapter 2, "SIMPROCESS Basics," beginning on page 63, can be divided into two categories: Entity Related and Resource Related.

Entity Related

These Activities coordinate groups of Entities and includes:

- *Assemble*. Receives two or more Entities and assembles them into a single Entity that is released.
- *Branch*. Routes Entities through different Connectors of the model network.
- *Merge*. Routes Entities from different Connectors onto one Connector.
- *Batch*. Stores Entities until conditions set by the user are met, and then releases the Entities in one batch. The Entities emerge as a single unit, but retain their individual Entity identification.
- *Unbatch*. Separates a batched Entity into its constituent parts (Entities).
- *Split*. Divides an Entity into parent and child Entities that can undergo parallel processing.
- *Join*. Reunites families of Entities that were created in Split Activities
- *Transform*. Transforms an arriving Entity into a different Entity type, and releases one or more Entities of the new type.
- *Transfer*. Routes an entity from one model layout to another model layout without using a connector.

- *Clone*. Makes duplicate copies of Entities.
- *Gate*. Accumulates Entities until a condition is met and then releases a specified number of them.
- *Assign*. Assigns values to global Entity and Model Attributes and sets Entity priorities.
- *Synchronize*. Coordinates the release of various Entities.

Resource Related

Unlike other SIMPROCESS Activities, these Activities affect Resources, not Entities:

- *Replenish Resource*. Adds capacity to consumable Resources.
- *Get Resource*. Obtains a Resource and holds on to it across several Processes and Activities.
- *Free Resource*. Releases Resources obtained by Get Resource Activities.

Resource-related Activities are described in Chapter 5, "Resource Modeling Constructs," beginning on page 147. The Entity-Related Activities are covered in this chapter.

Entity-Related Activities

Activities that are used to coordinate grouping of Entities are addressed here. The type of coordination to be done is specified at the Activity. Entities are queued up in these Activities (except for Unbatch and Split) until the conditions are met. This queueing time is reported as "Hold for Condition" in the reports. This is reported separately from the "Wait for Resource" queueing time which can accumulate at any Activity for which a Resource requirement has been specified.

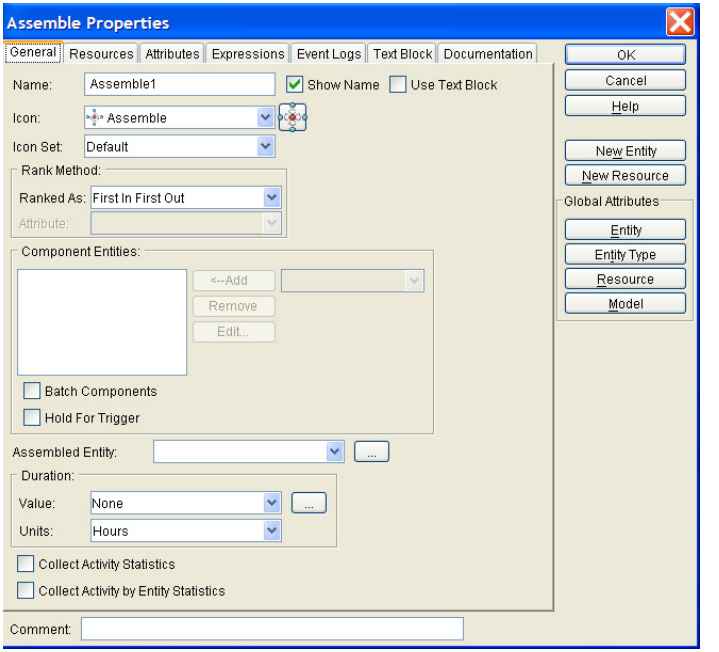
- Assemble Activity
- Batch Activity
- Unbatch Activity
- Gate Activity
- Synchronize Activity
- Split Activity
- Join Activity

Assemble Activity

The Assemble Activity is used to build several Entities into a single output Entity. Consider a case where two approvals and a check are required to form one "approved loan." An Assemble Activity can be used to model this process.

Assemble has two input Pads (*Component* and *Trigger*) and two output Pads (*Out* and *NoMatch)* that determine Entity behavior. The Component Pad places incoming Entities into a queue until all Entities to be assembled have arrived. An Entity entering the Component Pad not on the component Entity list will immediately leave the Assemble Activity through the NoMatch Pad.

The Trigger Pad is only relevant if **Hold for Trigger** is selected as one of the Activity's options. Entities entering the Trigger Pad can trigger the release of the assembled Entities. Assembled Entities are only released when an Entity, such as a Customer Order, arrives at the Trigger Pad. The trigger can be released by using the `FireTrigger` System Method instead of having an Entity enter the Trigger Pad. The name of the Activity must be unique within the model for the system method to work properly. See "SIMPROCESS System Methods" on page 521.



Dialog Field Definitions

Rank Method sets the rank method of the queue for the Entities to be assembled. There is a separate queue for each component Entity type. The rank method is the same for all queues. The default is **First In First Out**. The rank methods are:

- **First In First Out**
- **First In Last Out**
- **Earliest Created First**
- **Latest Created First**
- **Highest Priority Value First**
- **Lowest Priority Value First**
- **Highest Attribute Value First**
- **Lowest Attribute Value First**

Selecting **Highest Attribute Value First** or **Lowest Attribute Value First** will cause the **Attribute** field to be active. Select the desired attribute from the list. If the selected attribute is a local Entity instance or Entity type attribute, a run time error will occur if an Entity enters that does not have the selected attribute defined.

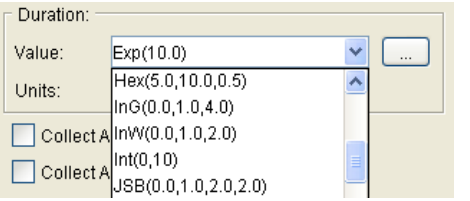
Component Entities is a list of component Entities to be converted to assembled Entities. Entities on

the list are queued until the specified quantity of each Entity type has entered the Assemble Activity.

- **Add:** Opens a dialog to define component Entities
- **Edit:** Opens a dialog to modify the component Entity definition
- **Remove:** Removes the selected component Entity
- **Batch Components:** When selected, the assembled Entity batches the component Entities. When not selected, component Entities are disposed when the assembled Entity is released.
- **Hold for Trigger:** Holds output Entities until an Entity enters the Trigger Pad.

Assembled Entity shows the Entity type to be released after all component Entities have entered the Activity. A combo box provides a list of defined Entity types.

Duration specifies the delay time of the Activity. The time set in the **Duration** will be applied after the Assembled Entity has been created. Thus, the **Duration** will be reflected in the Cycle Time of the Assembled Entity.

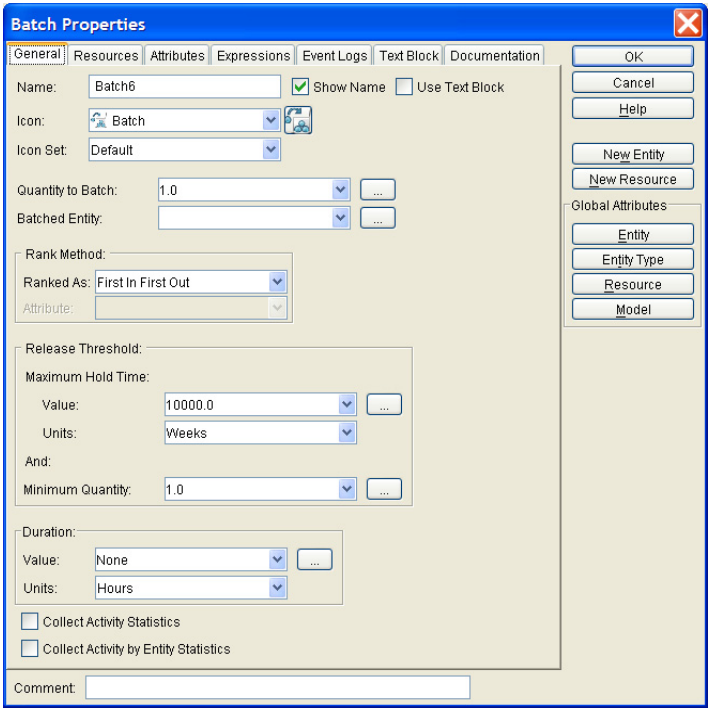


- **Value:** The amount of time required to perform this Activity. Use the combo box to select a statistical distribution or enter a constant value directly in this field.
- **Units:** Determines if the **Duration** entered is measured as nanoseconds, microseconds, milliseconds, seconds, minutes, hours, days, weeks, months, or years.

Batch Activity

The Batch Activity combines several Entities into one Entity while retaining the identities of the original Entities. The resultant Entity travels throughout the process as a single Entity. It can be disassembled into its constituent Entities using an Unbatch Activity at some later time.

The Batch Activity is useful when combining several Entities (e.g., merchandise ordered by various customers) into a parent Entity for transportation. After the transportation Activities, the parent Entity can be broken down into the Entities that comprised it. Statistics can be collected for the batched Entity separately from its constituent members.



Dialog Field Definitions

Batched Entity is the type of Entity that will serve as the container or *parent* Entity. An Entity of this type is created and all other Entities become children of the parent.

Quantity to Batch is the maximum number of Entities that fit in one batch.

Maximum Hold Time: is the maximum amount of time to hold before a batch that has met the **Minimum Quantity** requirement is released.

Minimum Quantity is the minimum number of Entities that must be in a batch before it can be released.

Duration is the time specified for a Batch Activity that will be applied after the Batched Entity has been created. It will be reflected in the Cycle Time of the Batched Entity.

Rank Method sets the rank method of the queue for the Entities to be batched. The default is **First In First Out**. The rank methods are:

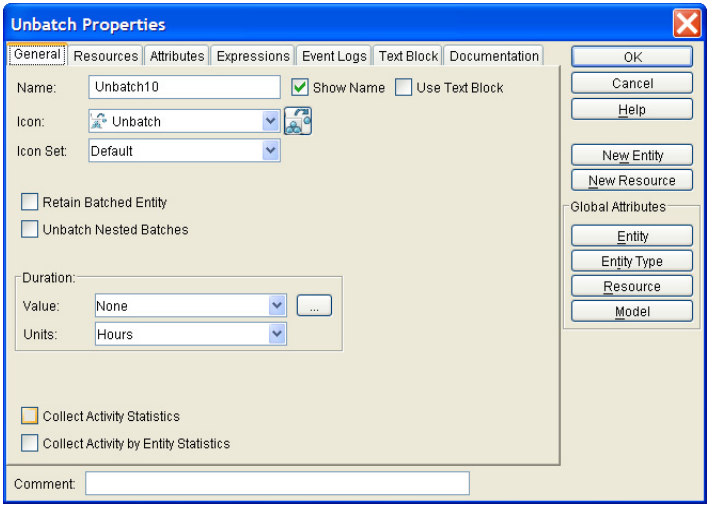
- **First In First Out**
- **First In Last Out**

- **Earliest Created First**
- **Latest Created First**
- **Highest Priority Value First**
- **Lowest Priority Value First**
- **Highest Attribute Value First**
- **Lowest Attribute Value First.**

The **Attribute** field will be active if **Highest Attribute Value First** or **Lowest Attribute Value First** is selected. Select the desired attribute from the list. If the selected attribute is a local Entity instance or Entity type attribute, a run time error will occur if an Entity enters that does not have the selected attribute defined.

Unbatch Activity

An Unbatch Activity separates a batch Entity into its constituents (children) and then destroys (*Disposes*) the parent Entity. Many levels of batching are possible, i.e., batches can be composed of batches. The Unbatch Activity defaults to only disaggregate one level of batch at a time. **Unbatch Nested Batches** must be selected to disaggregate all levels.



The time specified in the **Duration** will be applied before the unbatching occurs. It will be reflected in the Cycle Time of the Batched Entity.

The Unbatch Activity defaults to disposing the Batched Entity that enters the Activity. **Retain Batched Entity** must be selected for the Batched Entity to not be disposed,. The Batched Entity will continue

through the simulation with no child Entities.

Gate Activity

The Gate Activity accumulates Entities until some number of Entities have been received or until a signal is received to release Entities. It then sends a designated number of Entities out into the model. Entities can be batched in a Gate Activity.

A Gate Activity has two Pads that determine Entity behavior, the *Hold* Pad and the *Trigger* Pad. The Hold Pad, located on the lower left of the Gate icon, is a queue for incoming Entities. Entities that arrive at that Pad are stored here. The Trigger Pad, located on the upper left of the Gate icon, signals release of Entities.

A Gate Activity has two gating policies that can be effective concurrently. The first gating policy is called **Trigger Release**. An Entity is disposed of when it arrives at a Trigger Pad, and it triggers the release of the number of Entities as specified in the **Trigger Release Quantity** field. A Trigger Pad can synchronize the flow of Entities between different Activities.

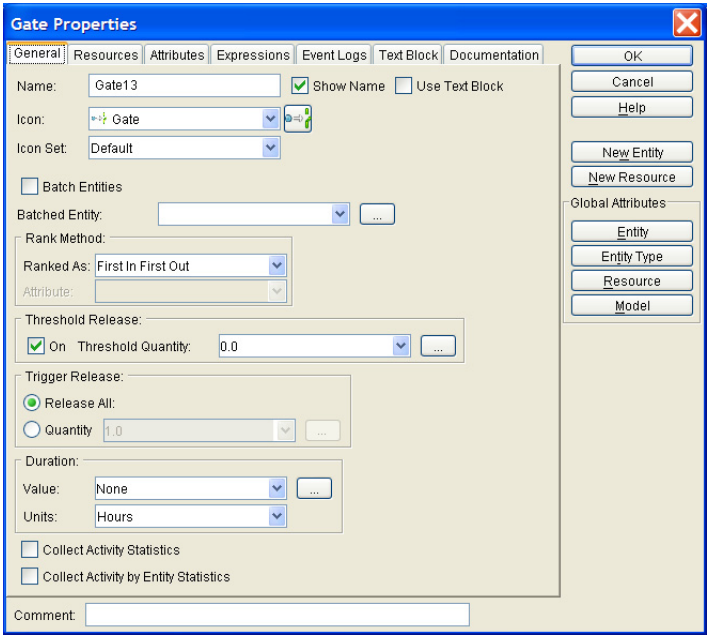
The Gate Activity can be used as a buffer or queue to hold material from one section of the model until a condition is met in another part of the model. A Trigger Entity is sent to the Trigger Pad of the Gate Activity when that condition is met.

An example of this would be if customer orders are printed out and sent on to the shipping department on an hourly basis. This could be reflected in the model by a Gate Activity, which is triggered when it receives an Entity that is generated hourly by a Generate Activity.

The second gating policy is called **Threshold Release**. It allows the release of some number of Entities once a threshold number of Entities have arrived. This policy is useful, for example, in cases where a truck must wait until it is full before it departs.

Gating policies can be effective concurrently, so this Activity can implement a truck leaving when it is full or on the hour, even if it is not full.

Note that Entities can be released from Gate Activities using Expressions. See Chapter 10, “Customizing a Model with Attributes and Expressions,” beginning on page 237 for information on Expressions. Also, see “Methods ReleaseEntity, Gate, GetEntity, EntityExists:,” beginning on page 568.



Dialog Field Definitions

Batch Entities will batch the Entities before leaving the Activity.

Batched Entity is the type of Entity that will serve as the container or *parent* Entity. An Entity of this type is created, and all other Entities become children of the parent.

Rank Method sets the rank method of the queue for the Entities waiting at the Gate. The default is **First In First Out**. The rank methods are

- **First In First Out**
- **First In Last Out**
- **Earliest Created First**
- **Latest Created First**
- **Highest Priority Value First**
- **Lowest Priority Value First**
- **Highest Attribute Value First**
- **Lowest Attribute Value First**

The **Attribute** field will be active if **Highest Attribute Value First** or **Lowest Attribute Value First** is selected. Select the desired attribute from the list. If the selected attribute is a local Entity instance or Entity

type attribute, a run-time error will occur if an Entity enters that does not have the selected attribute defined.

Threshold Release

- **On/Off:** Enables/disables the **Threshold Release** feature. **Threshold Release** is on when the check box is selected.
- **Threshold Quantity:** The threshold number of Entities to accumulate and release when the **Threshold Release** is checked on.

Trigger Release

- **Release All:** Releases all the accumulated Entities when a Trigger Entity has been received on the Trigger Pad.
- **Quantity:** The number of Entities to release when a Trigger Entity has been received on the Trigger Pad. This is used with the Trigger Release policy. The value can be a constant integer or can be derived from a statistical distribution.

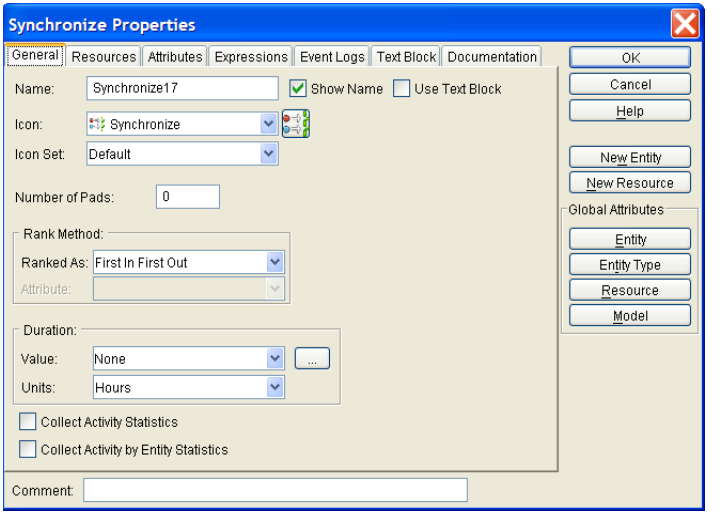
The Trigger can be released by using the `FireTrigger` System Method instead of having an Entity enter the trigger Pad. The name of the Activity must be unique within the model for the system method to work properly. See "SIMPROCESS System Methods" on page 521.

Duration is the time specified for a Gate Activity that will be applied when the Entities are released. Each Entity released will have a duration, unless the Entities were batched. In that case there is only one duration for the Batched Entity.

Synchronize Activity

A Synchronize Activity coordinates the release of many Entities, which may be of various types. The number of input/output Pads for a Synchronize Activity is specified. Entities arriving at each Pad are stored in separate queues. Each queue releases one Entity to its corresponding output Pad when each queue has at least one Entity.

A project may require four jobs to be done in parallel, with the work kept in step at various tasks within the process. All others must be at the same stage of completion before work can proceed on one job. Synchronize Activity may be used with four Pads to model the wait time and release of the parallel tasks.



Dialog Field Definitions

Number of Pads is the number of pairs of input and output Pads required by this Activity.

Rank Method sets the rank method of the queues for each input Pad. Each queue will have the same rank method. The default is **First In First Out**. The rank methods are:

- **First In First Out**
- **First In Last Out**
- **Earliest Created First**
- **Latest Created First**
- **Highest Priority Value First**
- **Lowest Priority Value First**
- **Highest Attribute Value First**
- **Lowest Attribute Value First**

The **Attribute** field will be active if **Highest Attribute Value First** or **Lowest Attribute Value First** is selected. Select the desired attribute from the list. If the selected attribute is a local Entity instance or Entity type attribute, a run time error will occur if an Entity enters that does not have the selected attribute defined.

Duration is the time specified for a Synchronize Activity that will be applied to each Entity when the Entities are released.

Entity Control Activities

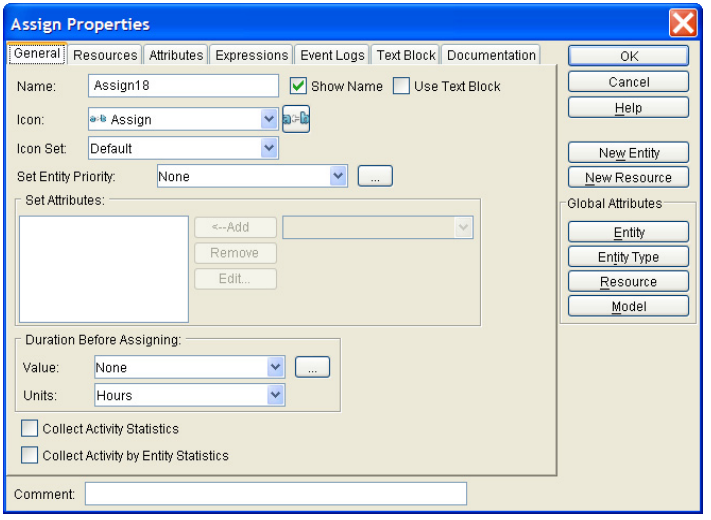
This section discusses Activities that are used in the control of Entities through the process model:

- Assign Activity
- Transform Activity
- Branch Activity
- Merge Activity
- Transfer Activity
- Clone Activity

Assign Activity

The Assign Activity is one method used to assign values to attributes. The Assign Activity can also be used to change the priority of an Entity.

The Assign Activity is covered in detail in "Assign Activity," beginning on page 250.



Dialog Field Definitions and Buttons

Set Entity Priority sets or changes the Priority of an Entity. The priority defaults to **None**, which means the Entity priority is not changed. Entity priority must be within the range 1 to 100. If a value less than

1 is returned from the distribution, then the Entity priority is not changed. If a value greater than 100 is returned from the distribution, then a warning is displayed, and the Entity priority is set to 100.

NOTE: Entities with a higher priority use available Resources first.

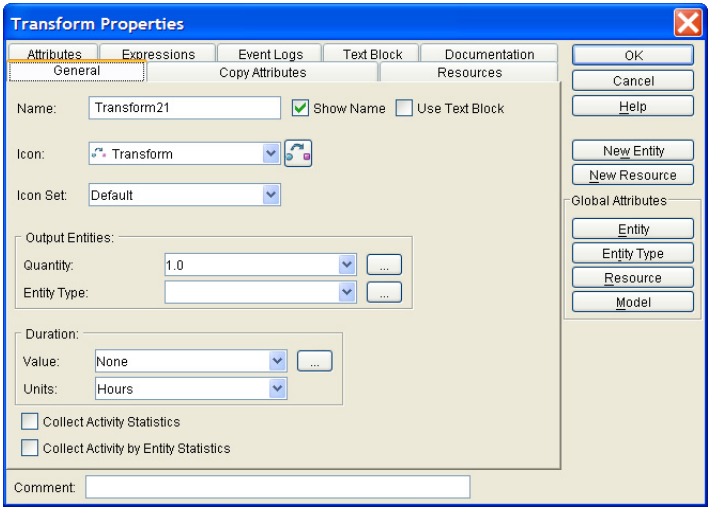
Set Attributes lists existing attribute assignments:

- Use **Add...** to set values for Entity attributes.
- Use **Edit...** to modify existing assignments. Select the attribute assignment you want to modify from the **Set Attributes** list.
- Use **Remove** to delete a previously defined assignment.

Duration is used as in other SIMPROCESS Activities.

Transform Activity

The Transform Activity changes one type of Entity into another type. A single arriving Entity can be changed into many output Entities (all of the same type.)



Dialog Field Definitions and Buttons

Output Entities

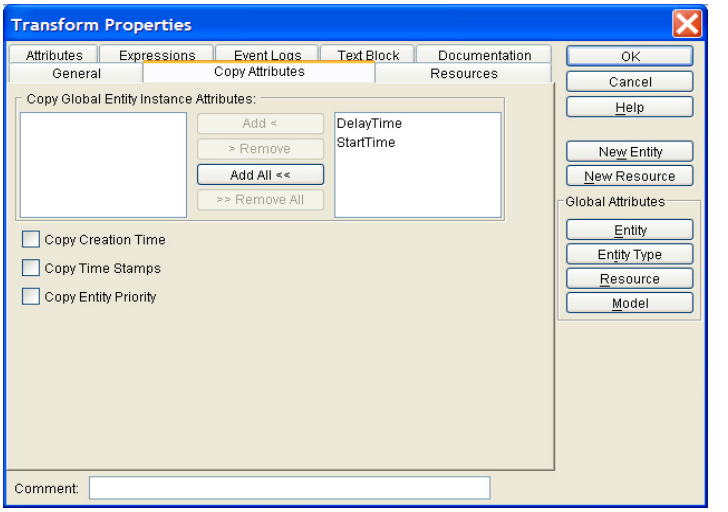
- **Quantity** is the number of new Entities to create. This number of each Entity arriving will be generated for *every* Connector exiting the Activity.

- **Entity Type** is the type of Entity to be released. Select the type from the pull-down list.
- The time specified in the **Duration** will be applied before the transform occurs, thus it will be reflected in the Cycle Time of the incoming Entities. The outgoing Entities will not have accrued any Cycle Time.

Copy Attributes tab is where attributes of the arriving Entity can be selected to be transferred to the new output Entity. Examples of attributes that can be copied include User Defined Attribute values, creation time, etc. Time Stamps and Entity Priority can also be copied.

Specifying Attributes to Copy

Selecting the **Copy Attributes** tab displays the following:



The following options on the **Copy Entity Fields and Attributes** tab can be selected:

- **Copy Creation Time** copies the simulation creation time of the original Entity to the transformed Entities.
- **Copy Time Stamps** applies the list of predefined timestamps carried by the arriving Entity to transformed Entities.
- **Copy Entity Priority** applies the priority of the arriving Entity to transformed Entities.

The transformed Entity receives the default Priority value defined in the Entity Type unless it is copied.

User Defined Entity Attribute values associated with the incoming Entity may also be copied. During simulation, different variable types (Integer, Real, Boolean, and String) can be added to an Entity.

Click on **OK** when finished to leave the dialog, confirming your current selections. The **Cancel** button cancels the current dialog selections.

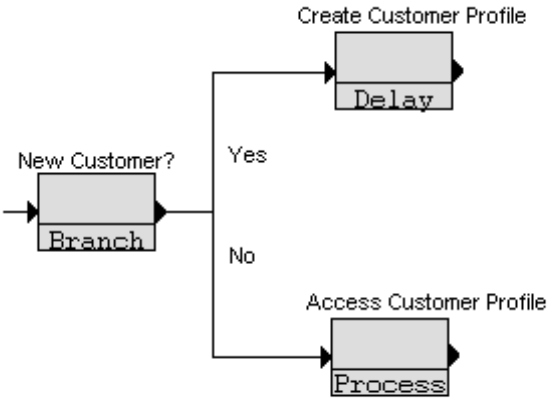
Branch Activity

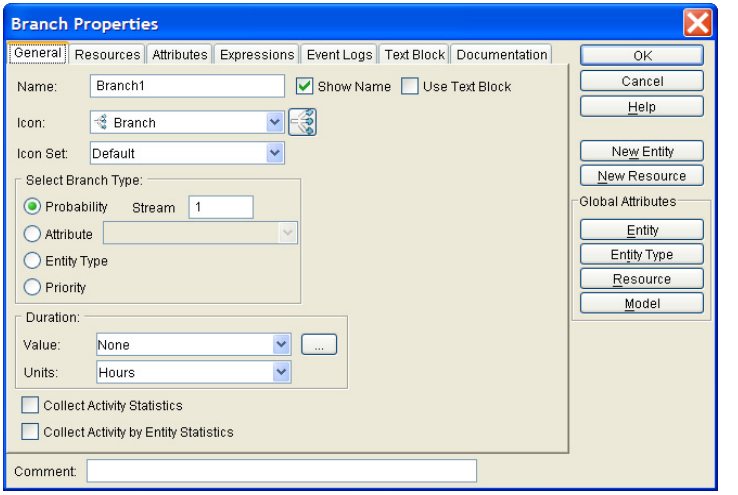
A Branch Activity routes Entities to different paths of the process model. It allows modelling decision processes, with alternative pathways selected depending on the result.

In the **Branch Activity** detail dialog, you select the type of branching criteria to use: **Probability**, **Entity Type**, **Attribute** value, or **Priority**. The precise criteria are specified on the Connectors associated with the Branch.

Consider the case where the order fulfillment process for new customers requires a step that is not needed for repeat customers, such as creating a customer profile. Use different Entities for new customers and repeat customers and branch on **Entity Type**.

Or use a single Customer Order Entity and assume that a certain percentage of customers are new and a certain percentage are repeats. Select **Branch Type Probability** and then set the probability of each event on the Connectors leading from the Branch output Pad:





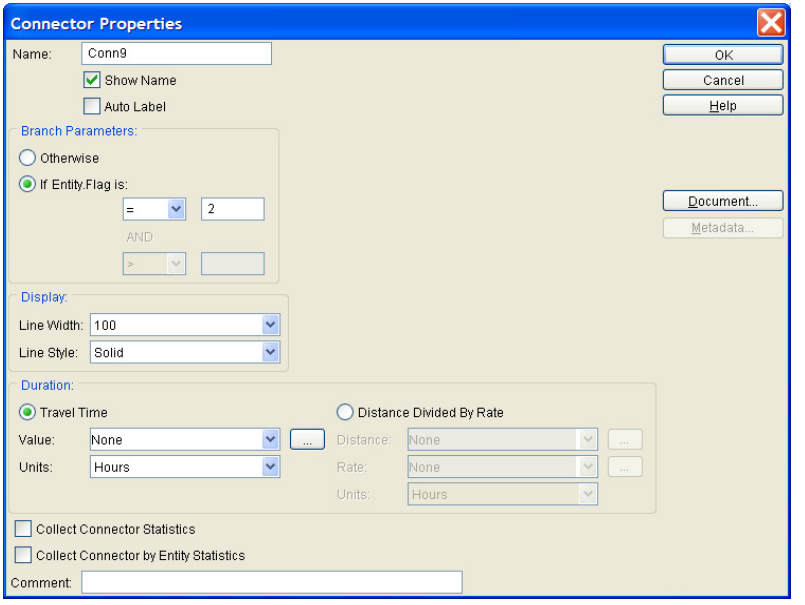
Dialog Field Definitions and Buttons

Select Branch Type

- **Probability.** Entities routed based on a probability specified on each Connector leading from the Branch. All probabilities must sum to 1.0, or one of the Connector's should have the **Otherwise** field set to **True**. **Stream** is the random number stream to use for the probabilities.
- **Attribute**. Route Entities to the appropriate Connector based on values of User Defined Attributes or System Attributes. (See "Using Attributes in SIMPROCESS," beginning on page 241 for more information on User Defined and System Attributes.)
- **Entity Type**. Route Entities based on type, e.g., send Orders one way and Bills another. Set the Entity Type on the Connectors emanating from the Branch.
- **Priority**. Ability to route higher priority items on one path, lower on another. The priorities are specified on the Connectors.

Branch Connectors

Connectors link Activities and Processes together. Connector names can assist in labeling a model, e.g., the Entity type that flows. SIMPROCESS will automatically label Connectors emanating from Branch Activities. (See "Connectors and Branch Activities" on page 135 for details.)



The **Branch Connector Properties** dialog contains the **Name** of the Connector, **Comment**, the **Line Width** and **Line Style**, **Branching Parameters, Duration**, **Collect Connector Statistics**, and **Collect Connector by Entity Statistics**.

To display the **Connector Properties**, either double-click on the Connector, right click on the Connector and choose **Properties**, click to select the Connector and click the **Properties** button on the tool bar, or click to select the Connector and choose **Properties** on the **Edit** pull-down menu.

Connector Names

A default Connector name, e.g., Conn44 is assigned. To change the Connector Name, edit the **Name** field in the Connector properties. The **AutoLabel** check box is discussed below.

Displaying Connector Names

The **Edit Preferences** option, on the **Edit** pull-down menu, determines if Connector names are displayed in the model. However, individual **Connector** dialogs have **Show Name** check boxes that will override the model default.

The **Name** field is displayed across the middle of the Connector if **Show Name** is selected.

The **Auto Label** check box applies only to Connectors from Branch Activities. The **Name** will be generated by SIMPROCESS. SIMPROCESS uses entries in the **Connector Detail** dialog box depending

on the **Entity Type**.

Connectors and Branch Activities

There are additional fields that appear in the **Connector** detail dialog box when the Connector is connecting a Branch Activity to another Activity or Process. When a Connector emanates from a Branch Activity, use the **Branch Connector Properties** dialog box to specify the branching parameters.

The corresponding **Connector Properties** are based on the type of Branch selected in the **Branch Activity Properties** dialog.

Entity Type —Select the type of the Entities that should flow along this Connector from the combo box.

Probability —Enter the probability (a number between 0 and 1.0) that the Entity will flow on this Connector.

Priority — Enter the Entity priority number to branch on. Values are from 1 to 100.

> When Entities are contending for Resources, Entities with a higher priority get to use available Resources first. The higher the number, the higher the Entity's priority.

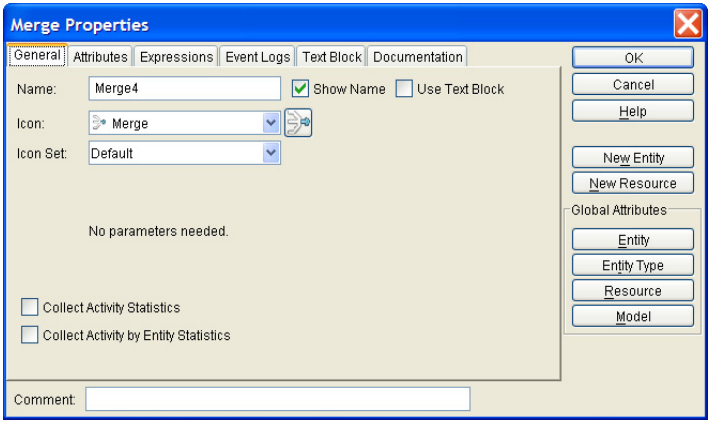
Attribute —The first line shows the name of the Attribute selected in the **Branch Properties** box. Branching can be based on the equality of numbers, strings, booleans, or on ranges of numbers. If the selected Attribute is a local Entity instance or Entity Type attribute, a run time error will occur if an Entity enters that does not have the selected Attribute defined.

Otherwise —If **Otherwise** is selected, this Connector becomes the default branching Connector. This means all Entities pass through this Connector if none of the criteria in any other Connectors are satisfied.

Branch Activity Type	Connector Properties Used	Display Example
Probability	Probability (between 0 and 1.0) Otherwise (True or False)	0.75 Otherwise
Attribute	Branch If Attribute Is (value) Otherwise, (True or False)	Displays User Defined Attribute Name on Connector with IF or AND conditions, e.g. My Attr1 = 5, or 4 < My Attr1 < 7 Otherwise
Entity Type	Type (from Entity type combo box) Otherwise (True or False)	Request for Quote Otherwise
Priority	Priority (Entity Priority 1-100) Otherwise (True or False)	1 Otherwise

Merge Activity

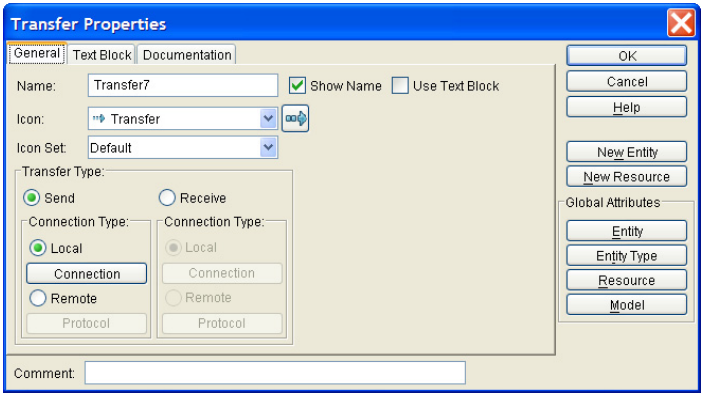
A Merge Activity routes Entities from different Connectors into one Connector. Merge can be used to TimeStamp all Entities or to reduce the number of "to and from" Connectors to create a more visually appealing model. Also, a Merge Activity is useful if groups of Activities will be copied and pasted. By using a Merge Activity, Connectors are not lost during the copy and paste.



Transfer Activity

A Transfer Activity routes entities without the use of a Connector. Entities can be routed within the same model (**Local**) or to other models (**Remote**) with theTransfer Activity. (**NOTE**: Although, the **Remote** capability is discussed, this capability has not yet been implemented.) The **Transfer Type** for a Transfer activity can be **Send** or **Receive**. A sender routes entities to a receiver. Thus, Transfer Activities should be used in pairs. Every sender should have an associated receiver. A sender can only connect with one receiver, but a receiver can have multiple senders connected to it. Each **Transfer Type** designates a **Connection Type** of **Local** or **Remote**. **Local** means the entity transfer will occur within the same model. A **Send** Transfer Activity that is designated **Local** can only connect with a **Receive** Transfer Activity in the same model that has also been designated **Local**. **Remote** means the entity transfer will occur between models. A **Send** Transfer Activity designated **Remote** can only connect with a **Receive** Transfer Activity in a different model that is also designated **Remote**.

When the activity is placed on the layout, it does not have an input pad or output pad. Selecting **Send** causes an input pad to be added to the activity. Selecting **Receive** causes an output pad to be added to the activity. Once the combination of **Send** or **Receive** and **Local** or **Remote** has been set, it cannot be changed. The activity must be deleted and recreated if either option needs changing. The default combination for a new Transfer Activity is **Send** and **Local**.

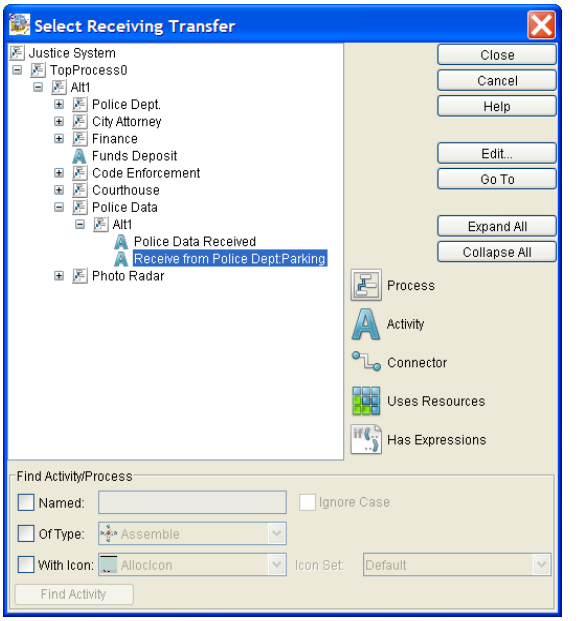


Dialog Field and Button Definitions

Transfer Type sets the Transfer Activity as **Send** or **Receive**. Both **Send** and **Receive** have a **Connection Type** (**Local** or **Remote**). The **Connection Type** options enable based on the selection of **Send** or **Receive**.

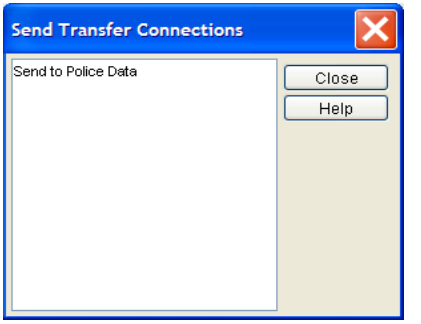
Connection Type sets the Transfer Activity as **Local** or **Remote**. The **Local** option has a **Connection** button associated with it, and the **Remote** option has a **Protocol** button associated with it. The **Connection** button is active when **Local** is selected, and the **Protocol** button is active when **Remote** is selected.

The **Connection** button for the **Send** option operates differently from the **Connection** button for the **Receive** option. Clicking the Connection button associated with Send/Local brings up a modified version of the Activity Browser dialog. (See "Activity Browser..." on page 35 for more information on using the Activity Browser.) This version includes a **Cancel** button.



All the functions of the dialog are the same as the Activity Browser dialog. Select the receiving Transfer Activity. (The **Find Activity/Process** section of the dialog can be used to search for Transfer activities.) The activity selected when **Close** is clicked must be a Transfer Activity with **Receive** and **Local** selected. An error will occur if the activity selected is not a Transfer activity with **Receive** and **Local** selected. Click **Cancel** to not make a selection or to keep the current selection. Although the selection of **Send** or **Receive** and **Local** or **Remote** cannot be changed once selected, the **Connection** can be changed once set.

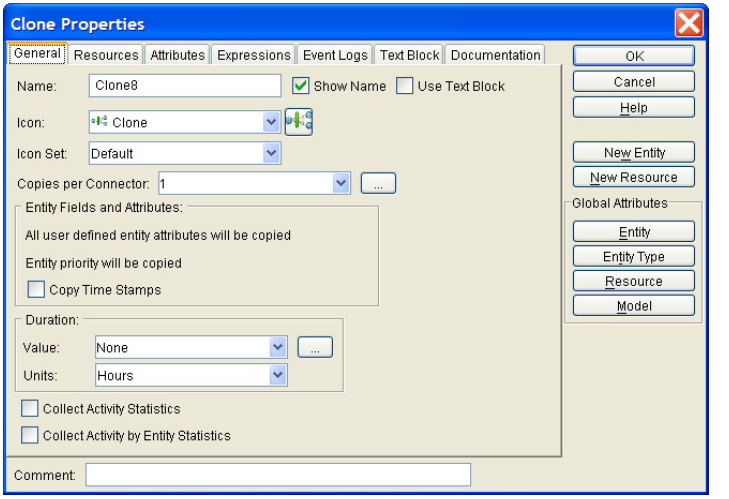
The **Connection** button associated with the **Receive** option displays a list of the **Send** Transfer Activities routing entities to that **Receive** Transfer Activity. No editing of the connections is allowed. The dialog is for informational purposes only.



The **Protocol** buttons will set the sending and receiving protocols for **Remote** transfers when the **Remote** capability is implemented.

Clone Activity

The Clone Activity generates duplicate Entities. Note that this activity is only available from the **Create** menu. This is because the Clone activity exists primarily to support pre-SIMPROCESS version 4.0 models. Since the cloned entities leaving the Clone activity are of the same type as the entity entering the activity, the entity statistics for the type of the entering activity are affected by the creation of the cloned entities. The entity statistics are skewed by the Clone activity. The Split activity is the recommended activity for entity cloning since the cloned entity can be a different type of entity. Thus the statistics for the original entity are not affected by the creation of cloned entities.



Dialog Field Definitions

- **Number of Copies per Connector** is the number of Entities that will come out the Clones Pad into *each* Connector.
- If a **Duration** is defined for the Activity, the time specified in the **Duration** will be applied before the cloned Entities are created. In other words, it will be reflected in the Cycle Time of the incoming Entities.
- If Time Stamps are defined for the incoming Entity, those values can be passed to the Clones by selecting **Copy Time Stamps**.

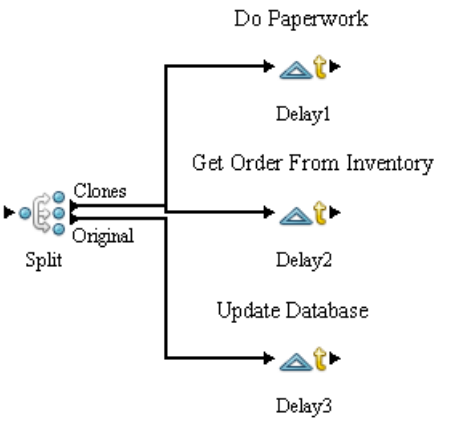
Split and Join Activities

The *Split* and *Join* Activities work together to temporarily split the processing of an Entity among parallel Activities.

At the Split Activity, an Entity is converted into two or more Entities, each of which follows a different path before (optionally) reuniting at a Join Activity.

The Split Activity generates *child* Entities from the *parent* Entity. The children and the parent Entity belong to the same *family*. After going their separate ways, the family is reunited at the Join Activity, where a single Entity, the *parent*, exits for continued processing.

In the order fulfillment process, Split and Join might come into play in the handling of rush orders. To speed up processing of rush orders, the work might be divided among several clerks at some point:

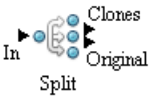


The figure above shows how a Split Activity takes a customer order Entity and releases three Entities,

the original and two children (or clones). Each Entity goes to a different Activity, where a different task is performed on the order.

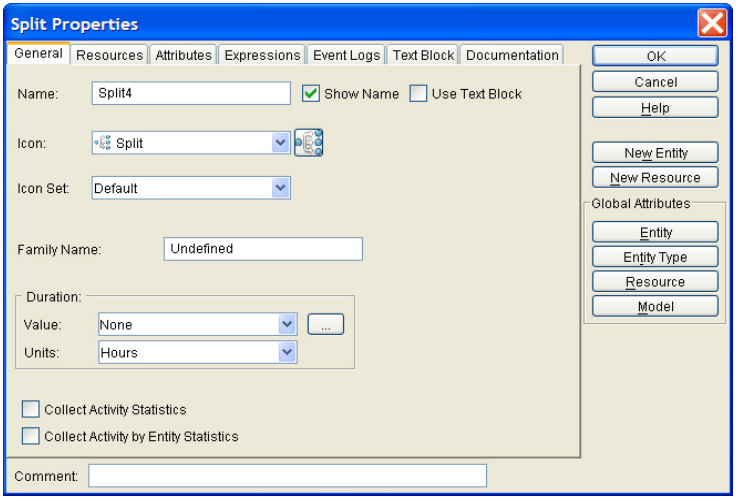
Defining a Split Activity

When you add a Split Activity to the SIMPROCESS layout, it has one input Pad and two output Pads attached:



The upper output Pad is named *Clones*; the lower Pad is named *Original* (if you double-click on the Pads, you will see their names in the **Pad Detail** dialog).

Use the Original Pad to route the original Entity to the next Activity in its path. Use the Clones Pad to route each of the split Entities to their next Activities. An unlimited number of split Entities of different Entity types can be released at a Split Activity, but all Entities emerge from the same Pad.



Dialog Field Definitions

The unique attribute of the Split Activity is:

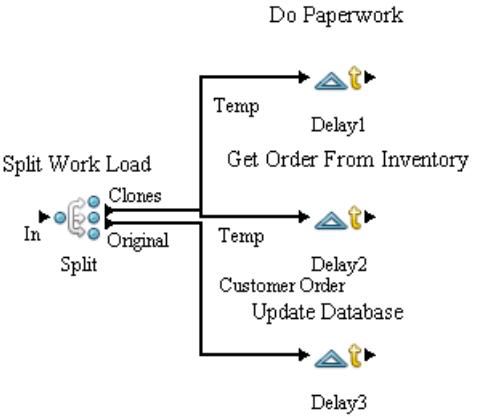
Family Name. This names the family of Entities being created. The original Entity and its children can be identified by their common family name. **Family Name** is used at a Join Activity to identify the Entities to be joined. Family names must be unique within a model.

Identifying Split Entities

Split Entities are Attributes of the Connector: a Split Entity is defined for each Connector linking a Split Activity to a connecting Activity.

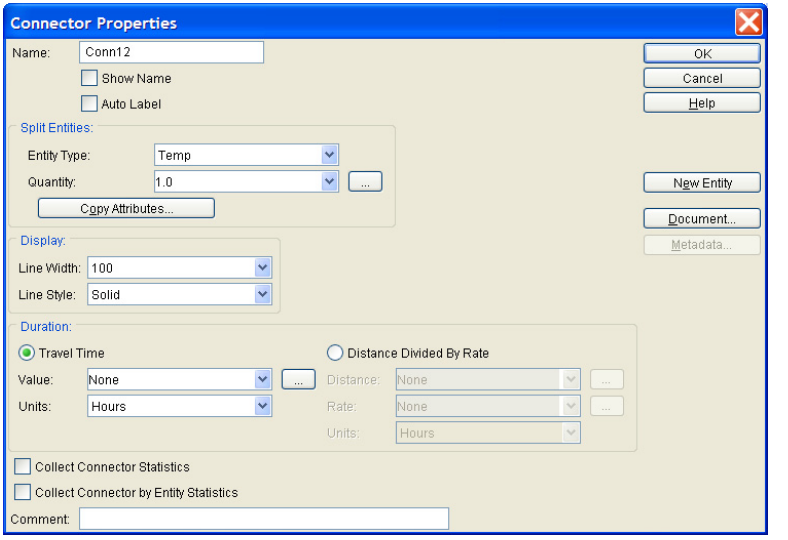
A single Connector is drawn from the *Original* output Pad to an adjoining Activity's input Pad. Then, the *Split* output Pad is connected to the other adjoining Activities.

As an example, the figure below shows the distribution of rush order processing into three simultaneous Activities: paper work, retrieval of an item from inventory, and updating of the inventory database.



The *Original* Pad of the Split Activity is connected to the input Pad of the *Update Database* Activity, so the original customer order Entity flows through *Update Database*.

Double-clicking on one of the Connectors emanating from the Split Pad opens the Split Connector properties.



Dialog Field Definitions

The unique attributes of the Split Connector are:

- **Entity Type** is the field where the Split Entity type that will flow along this Connector is selected.
- **Quantity** specifies how many of the split Entities will flow along this Connector for *each* original Entity that enters the Split Activity.
- **Copy Attributes** opens a dialog where Global Entity Instance attributes to copy from the original Entity to each of the Split Entities are selected. Entity Priority and Time Stamps can also be copied from the original Entity to each of the Split Entities.
- **New Entity** button opens the Entity definition dialog for modifying Entity-type definitions.

Clicking on the **Entity Type** pull-down box displays a list of the Entities in the model. The Entity to flow along this Connector is selected here.

For analysis purposes, consider using a different name for the children. For example, if the original Entity type *Customer Order* is used for each of the paths leading from the Split Activity, distortions in the statistics for the *Customer Order* Entity could occur. When all split Entities meet again at the Join Activity, the two split Entities are destroyed at the Join, while the original Entity continues on. When total cycle time for *Customer Order* Entities is calculated at the end of a simulation, those split Entities skew the statistics.

Cycle times for the split Entities are measured from generation in the Split Activity to termination in

the Join Activity, while the original Entity's cycle is measured from a Generate to a Dispose Activity.

An Entity named *Temp* is defined and used on the Split Connectors in the case of Rush Order Processing in order not to skew the cycle time or Entity count statistics for Customer Order Entities.

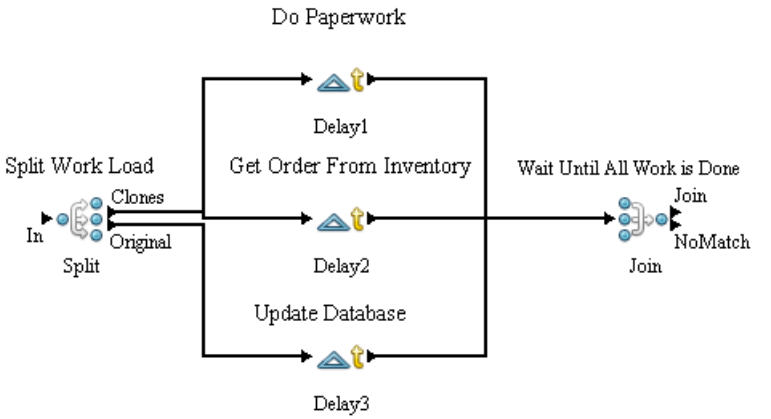
Note that using an Entity named *Temp* for split Entities is adequate if the simulation statistics of these Entities is not important. Define a different Entity type for each Split path if the number of each split Entity generated during a simulation is important, or any other Entity statistic is important.

Select the **Auto Label** option if you want SIMPROCESS to display the Entity name on the Connector. The name will be displayed unless **Show Name** on the Connector is turned off.

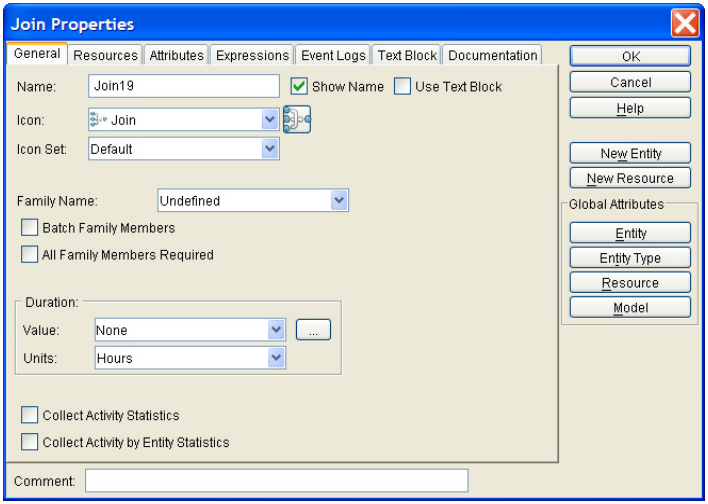
Click on **OK** when you finish defining the Connector.

Defining a Join Activity

Entities released from a Split Activity are reunited at a Join Activity.



The Join Activity icon has one input Pad and two output Pads. The upper output Pad is named *Join*; after reuniting with their family, the original Entity exits through this Pad. The lower Pad is named *NoMatch;* Entities that are not members of the Join family leave through this Pad. An Entity that is not a member of the Rush Order family that enters the Join Activity will pass through the Join Activity and exit through the NoMatch Pad. Note that no processing time will apply even if a delay duration is specified.



Dialog Field Definitions

Family Name identifies the Entity family to be joined. The pull-down list for **Family Name** contains the names of all families that have been defined in the model. Family names do not have to be unique in Join Activities, i.e., two Join Activities could use the same family name. This would be done if the same split Entities needed to be joined twice. The exiting Entity could be a batch that could be later unbatched and joined again after further processing.

Batch Family Members tells SIMPROCESS to batch the child Entities with the original Entity. The Entity could be separated into its components at an Unbatch Activity. Otherwise, all the child Entities are disposed in the Join Activity. SIMPROCESS releases the original Entity through the *Join* Pad.

By default, **All Family Members Required** is not selected. When the original Entity enters a Dispose Activity or is otherwise destroyed before it reaches a Join, SIMPROCESS releases one of the child Entities at the Join Activity. Which child Entity is released cannot be specified; SIMPROCESS selects it.

Note that if any of the child Entities are disposed before they reach their Join Activity, the rest of the family still reunites at the Join; if the rest of the family is already at the Join Activity at the moment the child Entity is destroyed, SIMPROCESS processes and releases the original.

If **All Family Members Required** is selected, then no Join will occur until all family members (children and parent) arrive at the Join Activity. Thus, if any members of the family are disposed before the Join, then the remaining family members will remain queued in the Join Activity.

CHAPTER 5

Resource Modeling Constructs

A Resource is an agent that is required to perform the tasks associated with an Activity. People, equipment, vehicles, money, and space can be modeled as Resources. The limited availability of Resources is an important constraining factor in business processes.

- A bank customer requires the help of a loan officer in order to submit a loan application.
- On a manufacturing line, a computer board cannot be populated with chips unless both an operator and a surface mounting tool are available.

The loan officer, the operator, and the surface mounting tools are Resources whose availability affects the activity in these examples.

SIMPROCESS provides the means for modeling Resources and for measuring the impact on the performance of a business process. In addition, variable and fixed costs associated with Resources may be used to measure Process costs and activity costs. See Chapter 7, "Activity-Based Costing," beginning on page 176 for more details.

This chapter describes how to:

- Define Resources
- Define groups of Resources for complex Resource requirements
- Define the Resource requirements of activities
- Use Resource related activities such as: Get Resource, Free Resource, and Replenish Resource.

Resources and Simulation

When an Entity arrives at an activity, SIMPROCESS checks to see if any Resources are required to process it. If Resources are required, SIMPROCESS attempts to obtain them. Once an activity gains control of one or more units of a Resource, those Resource units are unavailable to any other activity. The activity retains control of the Resource units until it finishes Processing the Entity.

Resource Allocation Policy

During simulation, many activities may simultaneously contend for units of the same Resource. If a required Resource is not available when an Entity arrives at an activity, the Entity waits for that Resource in a queue. This state is defined as “Wait for Resource” in the SIMPROCESS Standard Report.

If an activity requires units from two different Resources and units from only one Resource is available, SIMPROCESS may or may not obtain the Resource units that are available. It depends on the rules defined for the Activity. Any Resource units an activity holds are unavailable to other activities.

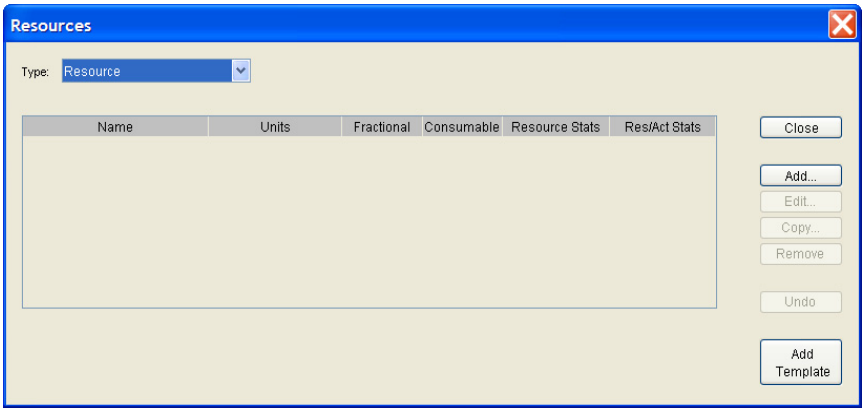
SIMPROCESS attempts to satisfy Resource requirements in the order of the priority of Entities queued for the Resource. Priority is an Entity attribute assigned when the Entity is defined. All Entities with the same priority are treated on a first-come, first-served basis. A higher priority Entity may (optionally) preempt a lower priority Entity when the Resource units needed are not available. See “Preempting Lower Priority Entities” on page 161.

Defining Resources

Use the **Resource** option from the **Define** pull-down menu, to define Resources in a model.

In the following discussion, Resources for an order distribution Process will be used: sales representatives to Process the orders, trucks to deliver merchandise, and fuel to power the trucks.

1. On the **Define** pull-down menu, select **Resources...**



The **Resources** dialog is used to define new Resources, modify existing Resource definitions, copy Resource definitions, or delete Resources. The **Add** function creates a new Resource definition. The **Edit, Remove**, and **Copy** functions are only active if there are existing Resource definitions. These functions operate on the Resource selected in the table:

Edit modifies an existing Resource definition.

Remove deletes a Resource definition.

Copy creates a new Resource based on the definition of an existing one.

Type specifies the Resource template that will be used to create a new Resource definition.

Undo restores a Resource that has been removed.

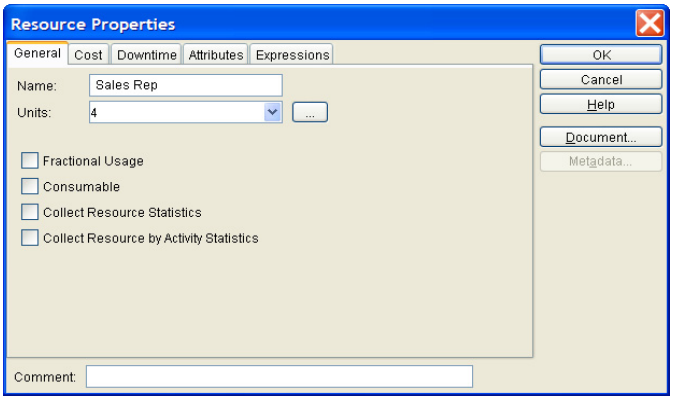
Add Template saves the Resource definitions for re-use. Templates are discussed in "Adding Resource Templates," beginning on page 230.

SIMPROCESS has one Resource type pre-defined which can be used when defining a new Resource. New Resource templates can be created and added to the **Type** list. (See "Adding Resource Templates," beginning on page 230 for more information on Resource Templates.) When the **Add** button is chosen, a new Resource with the characteristics of the **Type** selected will be created. The pre-defined type is a default Resource:

- One unit of resource.
- No downtime defined.
- No costs defined.
- No Attributes or Expressions defined.

See "Resource Downtime," beginning on page 343 for more information on Resource Downtime.

Click on **Add** to define a new Resource:



On the **Resource** dialog **Name** is any unique name identifying the Resource. Define the sales clerk staff, and name the Resource *Sales Rep*.

NOTE

Special characters, such as "/", "+", single quotes, or "-", should not be used in the **Name** of a Resource. This adversely impacts statistics and cost data collection.

Units identifies the initial capacity of the Resource. If the Resource is not consumable, capacity is constant throughout the simulation. If the Resource is consumable, capacity will vary over the length of the simulation. This fluctuation in capacity will be reflected in the capacity statistics in the Standard Report. Number of **Units** of a Resource can also be specified with a single line Expression, or a User-defined Attribute. See "Variable Resource Usage," beginning on page 252 for more information.

Fractional Usage indicates whether or not fractional units of the Resource can be allocated. If this box is checked, a non-integer value for **Units** (e.g., 2.5, 10.2) may be defined. It also means that an activity can acquire a fractional part of the Resource.

Consumable is used to identify resources that cannot be released and reused later, such as paper or oil. They must be replenished before demand is greater than supply.

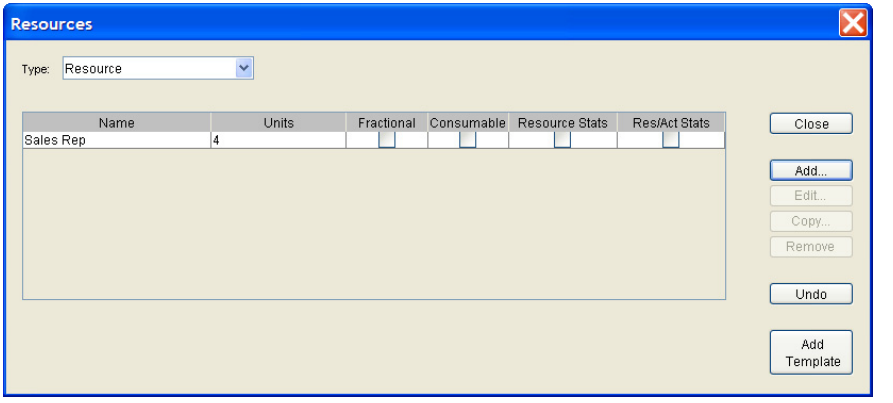
The **Cost** tab allows cost values to be assigned to Resources and keeps track of the expense involved in using Resources. This function is described in detail in Chapter 7, "Activity-Based Costing," beginning on page 176.

Expressions tab provides the means of writing specialized Processing instructions.

The **Attributes** tab defines attributes for the Resource. Attributes are customized variables. Typically, expressions include Processing of attributes. These topics are discussed in depth in Chapter 10, "Customizing a Model with Attributes and Expressions," beginning on page 237.

The **Document** function is used the same way it is for Activities, to store descriptive text about the Resource. The default headings can be customized. (See "document Subdirectory" on page 474.)

The **Downtime** tab is where the periods when the Resource will *not* be available in the model are defined. Resource downtimes are described in "Defining Downtime Schedules of Resources," beginning on page 347

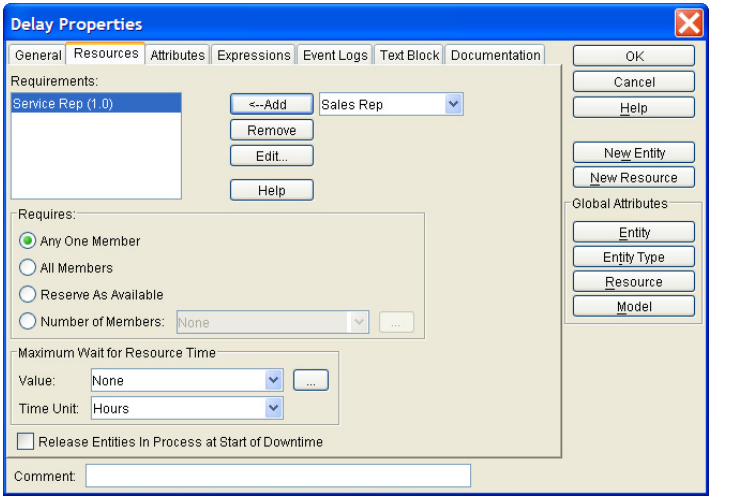


Note that the basic properties of Resources added to the model can be edited directly from the table. However, changes made in the table are direct changes to the properties of the Resource and cannot be canceled. Also, the table can be sorted by a particular column by clicking on the column header. Holding the **Shift** key while clicking on a column header causes the table to sort in the reverse order.

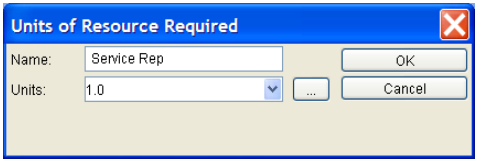
Adding Resource Requirements to Activities

Once the model flow and resources are defined, the Resource requirements of each Activity must be added to the model.

The Resource requirements for an activity are defined by double-clicking on the activity's icon to display the **Activity Properties** dialog box. On the dialog box, click on the **Resources** tab:



Add adds an individual Resource requirement for the activity. The units required default to 1.0 when a Resource is added. Use **Edit** to modify an existing requirement definition.



Any existing resources will be listed under the **Requirements** heading. Highlight the resource allocation to be modified, and press **Edit**. Units may be a constant or a distribution. Resource requirements can also be set by using the **Evl** function with User-defined Attributes. See "Variable Resource Usage" on page 252.

If the units requested are larger than the defined capacity of the Resource and the Resource is not a consumable Resource, a runtime error will occur. However, if the Resource is a consumable Resource, the Entity will remain in the wait for Resource queue. Entities remain in the wait for Resource queue

until the consumable Resource has been replenished to a level at or above the required allocation.

Remove deletes the requirement highlighted in the **Requirements** box.

Once a list of Resources has been chosen for the activity, the combination of Resources in the **Requires** area may be specified.

Requires defines the combination of Resources required to perform this activity:

- **Any One Member** — any one of the Resources listed is sufficient to perform the task.
- **All Members** — all members in the **Requirements** list are needed in order for this activity to Process an Entity. SIMPROCESS does not obtain any member until all the required Resources are available.
- **Reserve As Available** — all listed Resources are required and will be reserved as they become available.
- **Number Of Members** — A certain number of members of the list (but not all members) are needed to Process an Entity. Enter the value of number in the box.

> **Reserve As Available** may pose a risk of deadlock.
>
> Activities A and B are both defined as requiring Resources 1 & 2, using **Reserve As Available** logic. An Entity arrives at activity A, which obtains Resource 1. Resource 2 is not available, so A waits for it.
>
> Now an Entity with higher priority arrives at Activity B. Activity B waits for Resources 1 and 2. Then Resource 2 becomes available. Although Activity A has been waiting for Resource 2 longer than Activity B has, B gets the Resource because the Entity it is processing has a higher priority than Activity A's Entity. A deadlock develops since neither activity will release the reserved Resource. Make sure this situation cannot develop.

Maximum Wait for Resource Time is used to set the maximum amount of time an Entity will wait for the requested Resources to become available. The **Value** field can be None, a constant, or any valid statistical distribution and will represent units as selected in **Time Unit**. A **Value** of None indicates that the Entity will wait as long as necessary to obtain the requested Resources. If **Value** is something other than None and the Entity is still waiting for Resources when the specified time has passed, the Entity leaves the Activity without processing. When this occurs, the Entity System Attribute `EndWait` is set to TRUE. (See "Customizing a Model with Attributes and Expressions" on page 237 and "System Attributes" on page 512 for information on SIMPROCESS System Attributes.) Thus, `EndWait` can be checked to determine whether an Entity exited an Activity without processing and the Entity can

be routed appropriately. (**Important**: `EndWait` is not automatically reset to FALSE. This must be done in an Expression once the current value of `EndWait` is no longer needed for Entity routing.) For Activities that collect statistics, Entity Counts for Entities that exit without processing are displayed in the `Total Not Processed` category of the Activity Entity Count statistics (page 196) in the Standard Report (page 186). Note that there is also a `MaxWait` System Attribute that can be used to set the maximum amount of time that an Entity will wait for requested Resources (see "Setting Maximum Resource Wait With Expressions" on page 292).

Release Entities In Process at Start of Downtime sets whether Entities are released when Processing is interrupted by Resource downtime. This option is not available on the Resource usage dialog of the Get Resource activity. This is because Get Resource activities have no delay for Processing. See "Defining Downtime Schedules of Resources" on page 347.

Explicitly Getting and Freeing Resources

When an Entity arrives at an activity, if a Resource is listed in the Resource requirements list for the activity, SIMPROCESS attempts to obtain the Resource required to process the Entity. If the required Resource or Resources are not available, the Entity waits until the Resources become available. When processing is completed, the activity releases the Entity and frees the Resources.This is an implicit way to get and free a Resource. However, some business processes require more control over resource allocation. The Get Resource and Free Resource options allow the model to explicitly control the allocation of Resources.

A clerk may perform a series of activities, and it is necessary that the same clerk execute all the activities in a given order. Therefore, the model should "Get" the Resource, perform all the activities and then "Free" the Resource. The remainder of the section will describe how to model this series of actions with SIMPROCESS.

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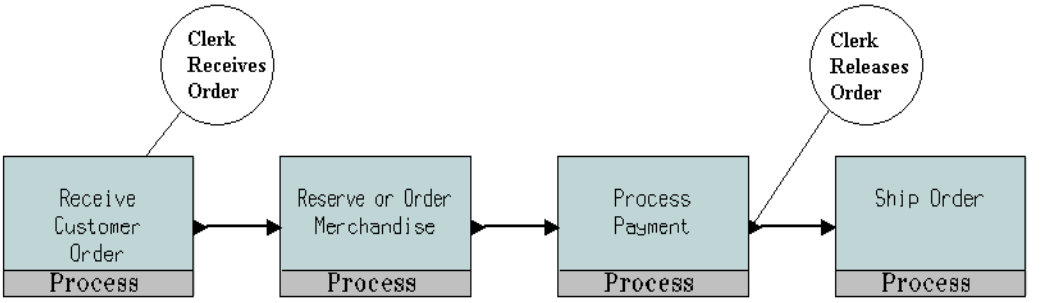


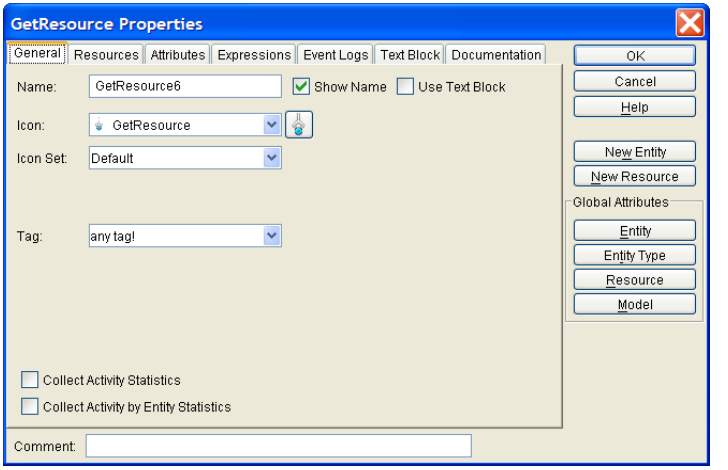
Get Resource and Free Resource Activities

Get Resource Activity

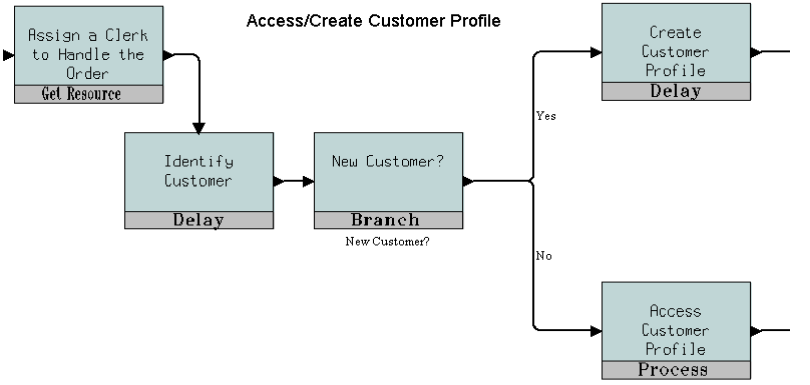
The **Get Resource** activity obtains a Resource and holds on to it across multiple Processes and activities.

Assign a unique **Tag** to each **Get Resource** activity. Although it is possible to use the same **Tag** twice at different levels of the model hierarchy, it is highly discouraged.

In the **Get Resource Activity Properties** dialog, click on the **Resources** tab to specify the Resources to be allocated. Fill out the **Resources Usage** dialog as specified in "Adding Resource Requirements to Activities" on page 152.



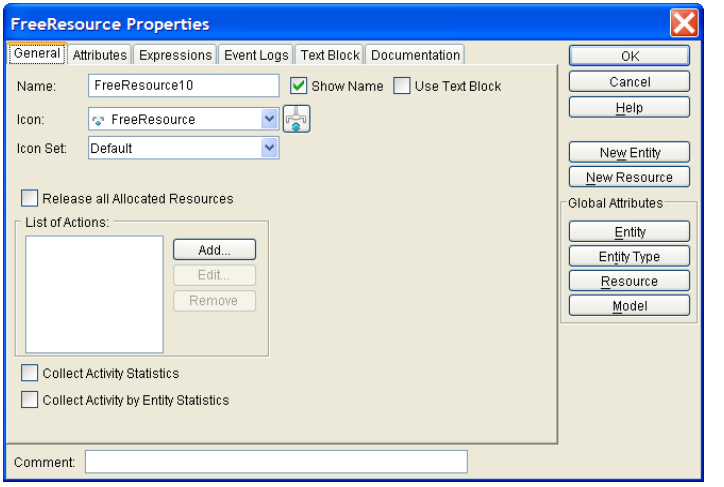
The *Access/Create Customer Profile* Process is shown with a Get Resource activity added:



Get Resource obtains Resources that would otherwise have been obtained in the ensuing activities. Do not define the same Resource requirement in those activities as well.

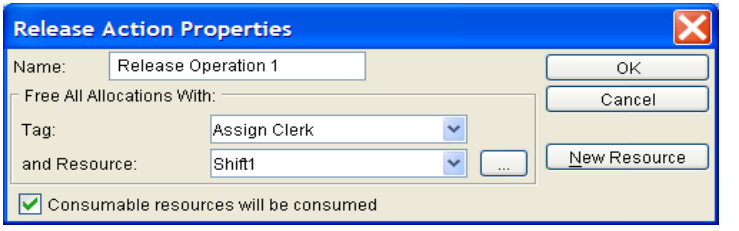
Free Resource Activity

The **Free Resource** activity is used to release Resources obtained at a **Get Resource** activity.



All Resources that have been allocated for this Entity can be freed by clicking on the **Release all Allocated Resources** box.

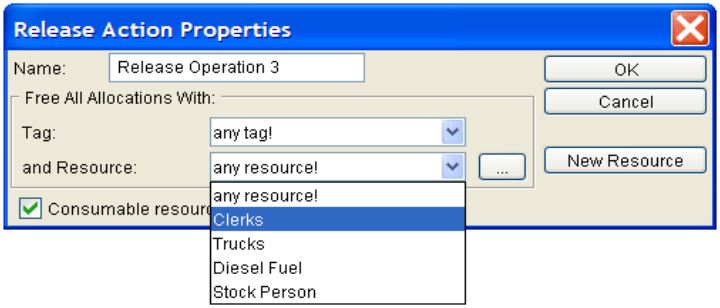
An explicit set of Resources to be freed can be defined by clicking on the **Add** button in the **FreeResource Activity Properties** dialog box. The **Add** button brings up the following dialog.



Assign a **Name** to the action being defined. This name will be displayed in the **List of Actions** field of the **FreeResouce Properties** dialog box.

The **Tag and Resource** fields combine to define free Resource actions:

1. **Tag** indicates the **Get Resource** activities whose Resources will be released. The pull-down list contains all the **Get Resource** tags in the model.



A tag may be selected from the listbox, or **any tag!** may be specified, which causes the free action to ignore the tag assigned at the Get Resource activity.

If more than one Get Resource activity was used, separate free actions can be defined for each set of Resources to be freed.

2. Use the **Resource** pull-down list to specify the Resource being freed, or select **any Resource!** to free all Resources allocated for the Entity. Resources are only freed if they were obtained in the activities specified in the **Tag** field.

   To release more than one Resource, but not all the listed Resources, create a separate action for each.

3. Select **OK** to accept the definition. The action now appears in the **List of Actions** schedule.

You can add additional actions to the list by clicking on **Add** and defining the action.To modify the definition for an action item, highlight it in the listbox and click on **Edit**. To remove the action, click on **Remove**.

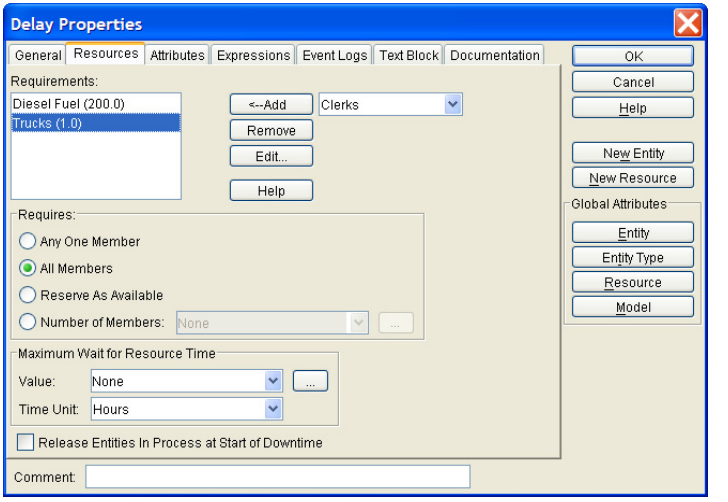
SIMPROCESS provides the option of whether or not to deduct the amount acquired from consumable Resources when those Resources are freed. Click on the **Consumable Resources will be consumed** check box in order to decrement consumable Resources. For example, a **Get Resource** activity obtains 50 gallons of Diesel Fuel in anticipation of shipping merchandise to a customer. Before reaching the shipping activity, the Entity enters a branch node in which the merchandise order is canceled. In this situation, one branch of the path leads to a **Free Resource** activity where the consumable Resource is not consumed, since it was not used. The other path continues on to the shipping activity, and then to a **Free Resource** activity in which the fuel Resource is consumed.

Getting and freeing Resources can also be accomplished using expressions. See “Getting and Freeing Resources Using Expressions” on page 281.

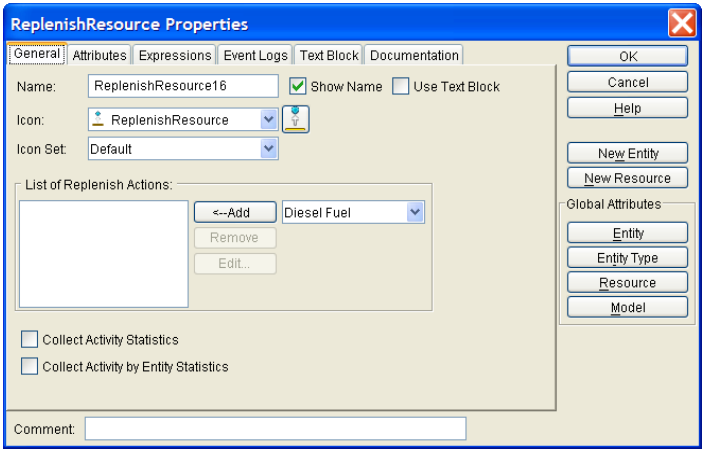
Replenishing Consumable Resources

The **Replenish Resource** activity is used to replenish a consumable Resource during a simulation.

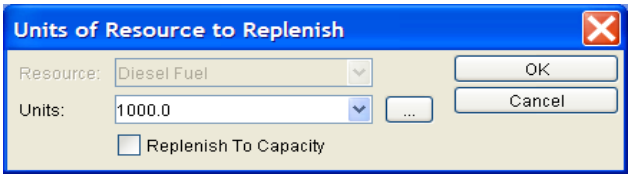
Diesel fuel is a consumable resource used when shipping merchandise. Once an order is made, the truck and a quantity of fuel will be allocated as Resources to perform the shipping. The fuel quantity is deducted from the inventory and gets replenished by a daily shipment received each morning.



Double-click on the **Replenish Resource** icon to define this action.



Select the consumable Resource on the drop down menu, and then click on **Add** to define a replenish action:



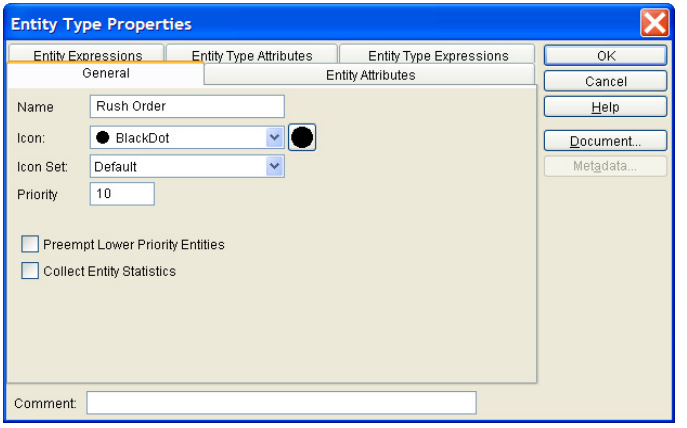
The **Resource** field identifies the Resource to be replenished. The pull-down list shows all the consumable Resources defined in the model.

Units indicates the quantity of the Resource to be added either in a real number or a statistical distribution. The distribution can be selected from the pull-down list of the **Units** field. The **Replenish to Capacity** box indicates that a Resource should be replenished only up to the value specified in its **Units** field when the Resource was defined.

Note that Resources can also be replenished using expressions. See "Changing Resource Capacity With Expressions" on page 291.

Preempting Lower Priority Entities

A higher priority Entity may preempt a lower priority Entity when the Resources are not available. Selecting Preempt Lower Priority Entities on the Entity definition dialog will potentially cause all Entity instances of this type to interrupt Activities processing lower priority Entities.



In this example, if a Rush Order Entity enters an activity that requires Resources, and no Resources are available, SIMPROCESS will check the Entities being processed. If there is a lower priority Entity Processing, the Processing will stop and the Resources will be released. When the Processing is stopped, if the **Interrupt Processing** Entity instance expression has statements, it is executed. The Rush Order Entity obtains the Resources and starts Processing. The Entity that was interrupted goes back to the wait for Resource queue. It will be placed in the queue ahead of all other Entities with the same or lower priority. When the interrupted Entity obtains Resources again, it will Process with the time that was remaining when it was preempted. Also, if the **Resume Processing** Entity instance expressions has statements, it is executed. (See page 275 for information on Entity instance expressions.)

CHAPTER 6

Graphical Modeling Constructs

Graphical constructs in SIMPROCESS include:

- Background Text (static and dynamic)
- Background Graphics

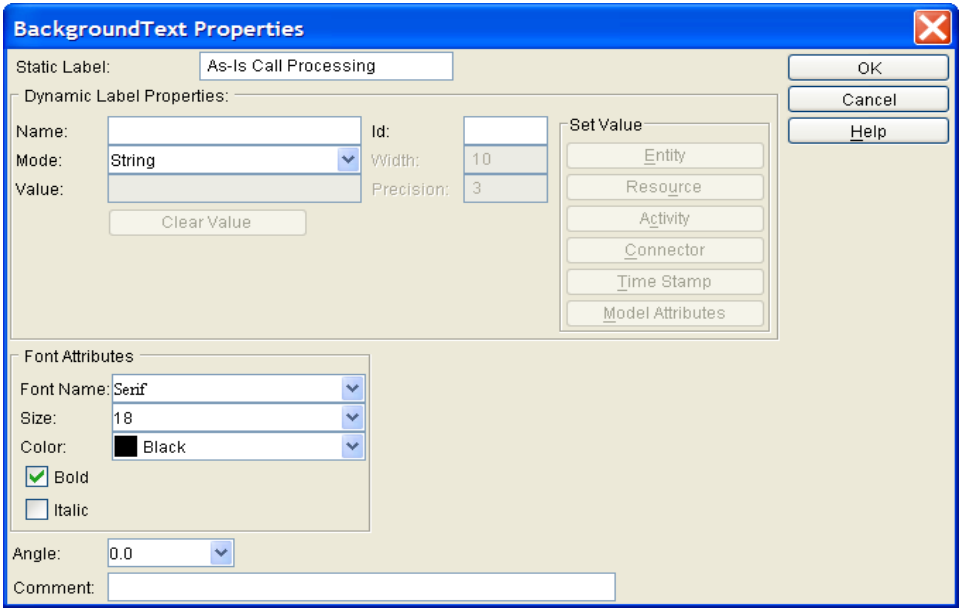
In addition, graphics can be imported for use as backgrounds or icons, and animation can be recorded for playback.

Background Text

There are two types of background text in SIMPROCESS: static text and dynamic labels. Static text is used for annotating the model layout and does not change during simulation. Dynamic labels are updated during simulation and are used to display information about changing properties of model elements. Several text labels can be grouped together on the layout and their horizontal and vertical alignment can be set using the **Align** option.

Dynamic labels can be updated automatically or by using the SIMPROCESS Expression Language. The SIMPROCESS Expression Language is an advanced feature found in SIMPROCESS Professional. Updating dynamic labels using expressions is covered in Chapter 10–Customizing a Model with Attributes and Expressions. This topic begins on page 237.

Properties are specified in the **Background Text** dialog, invoked by selecting a text tool from the Layout Toolbar (marked by a capital T) and clicking on the background in the location where text is to be placed. Text can be moved by clicking and dragging. The following shows a static label. Note that the **Static Label** field and **Font Attributes** are all that are required for a static label.



The dialog is divided into two sections: the top group of controls, designated as **Dynamic Label Properties,** is only applicable to dynamic text; the bottom group — **Font Attributes** — is used

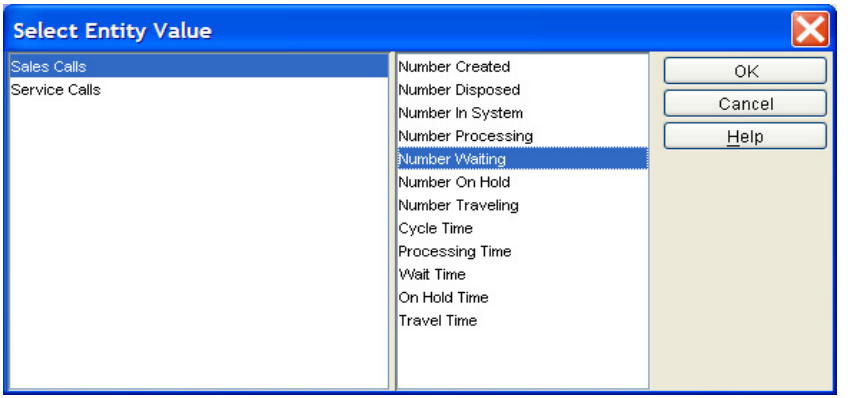
to specify all text properties. Defaults for the **Font Attributes** can be set on the **Background Text** tab of the Preferences dialog (**Edit/Preferences**).

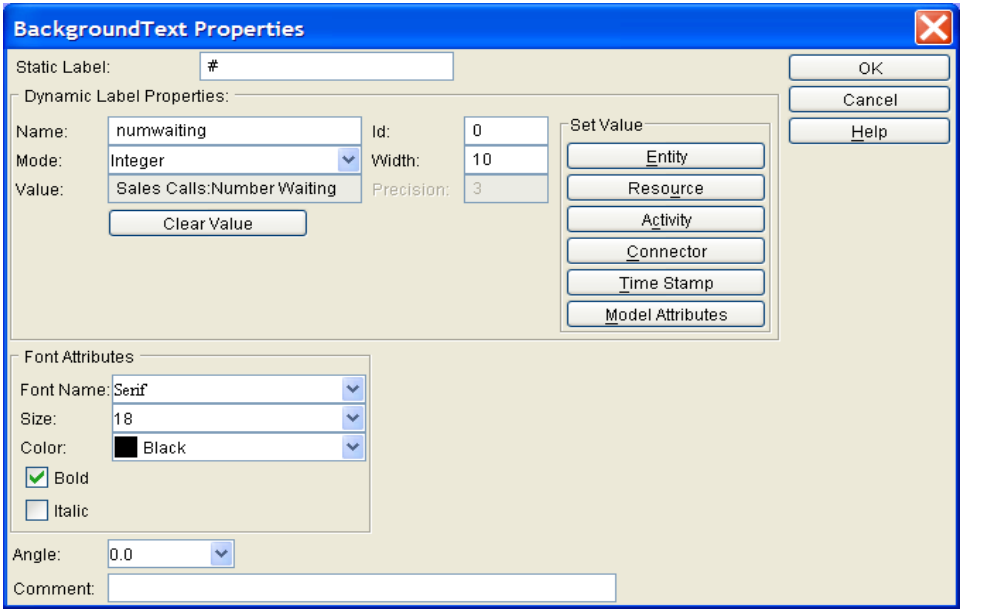
SIMPROCESS provides a list of the available fonts. Some fonts will not properly display their names in the combo box if the Java environment is unable to handle them. Avoid using these fonts. All rotation settings in the **Angle** combo box can be used with any font settings. Note that once the text is placed on the layout, the selection box around it has no handles. The only way to resize font text is to change its point size in the **Fonts** dialog. Once the text is placed on the layout, it can be moved, its properties edited, and it can be grouped with other objects on the layout.

When a dynamic label is placed on the layout, in addition to its font attributes, appropriate information needs to be entered in the **Dynamic Label Properties** group. Each dynamic label must have a unique combination of **Name** and **Id** number. Usually, **Id** number will be 0, unless two dynamic labels have the same name. The name typed into the **Name** text box will not appear on the layout. It will only be used to reference the label. Also, choose the type of value with which the dynamic label will be updated. The choice between String, Integer, and Real is made in the **Mode** combo box. If the value of the dynamic label is Real, also specify **Width** and **Precision** in the corresponding value boxes. **Width** is the total number of digits that will be shown for the displayed value (including the decimal point), while **Precision** specifies the number of digits after the decimal point that will be displayed. If the **Width** is greater than the value being displayed, it will be padded with spaces on the left side. If the **Mode** is Integer, then only the **Width** field needs to be set.

The **Value** field can be left empty. If so, the dynamic label can only be updated by using the SIMPROCESS Expression Language (page 294). Likewise, if the **Mode** is String, the dynamic label can only be updated through the SIMPROCESS Expression Language. If the **Value** field is not empty, the dynamic label will update automatically every time the selected value changes. The six buttons to the right (**Entity**, **Resource**, **Activity**, **Connector**, **Time Stamp**, and **Model Attribute**) are used to set the **Value** for the dynamic label. These buttons are active when a valid **Name** and **Id** has been entered and the **Mode** is not String. Each button brings up a dialog that lists each model element of that type (Entity, Resource, etc.) on the left. Once a value is selected on the left, the values available are listed on the right. Only one item can be selected on each side.

Selecting the **Entity** button displays the following dialog.





The **Value** field can be changed by selecting a different value using one of the six **Set Value** buttons. Select the **Clear Value** button to clear the **Value** field. As stated earlier, leaving the **Value** field empty means the dynamic label can only be updated using expressions.

Although it is not necessary, add a **Static Label** to the dynamic label definition. If this is not done, there will be no place holder for the dynamic label on the layout after the dialog is closed. This label can still be found by dragging a rubber band box in the selection mode around the area where it was placed. A very small selection box may appear at the location of the label.

The label's properties can then be edited by choosing **Edit/Properties** off the menu. Also, adding a static label to the side of the dynamic label makes it simpler to find the dynamic label location and provides a description of the value being updated. The static label is not replaced when dynamic value is updated since they are two separate labels.

Background Graphics

Select the Background Graphic icon from the Layout Toolbar and move it to the layout to add a background graphic. The **Select Background** dialog will open. Backgrounds can be previewed before adding to the layout by selecting a background then clicking the **Preview** button. Choose the background, and select **OK** to close the dialog. Once the graphic is on the layout, it can be resized by selecting **Edit/Resize**. Note that background graphics cannot be resized using the resize handles.

The properties of the Background Graphic has two options on the properties dialog, **Locked** and **On Top**.

The **Locked** option locks the Background Graphic to its current position on the layout, preventing inadvertent moving of the Background Graphic while editing or navigating. Background Graphics default to unlocked.

Turning the **On Top** option on brings the Background Graphic to the front of the layout display. Typically this option is left off, so that the Processes, Activities, and Connectors on the screen will appear on top of the Background Graphic.

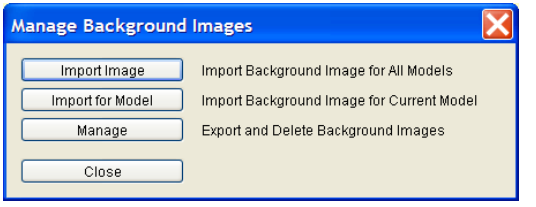
Note that Background Text added after a Background Graphic has been added to a layout will be behind the Background Graphic. If the Background Graphic is not transparent, the Background Text will not be visible. To solve this, make sure **Locked** is not selected, then select the Background Graphic and choose **Layout/Send to Back**.

Importing Graphics Image Files

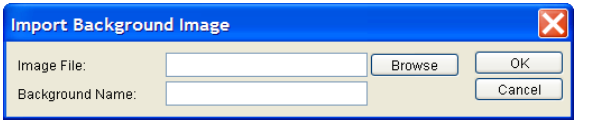
A Graphics Interchange Format (GIF), Joint Photographic Experts Group (JPEG), or Portable Network Graphics (PNG) graphic can be imported into SIMPROCESS. An imported graphic can be used as a Background Graphic, as an icon representing a Process or Activity, or as an icon representing an Entity.

Background Images

To use an imported graphic as a background, select **Manage Background Images** from the **Tools** menu. This will open the **Manage Background Images** dialog. The dialog has two actions for importing background images: **Import Image** and **Import for Model**. **Import Image** imports a background graphic for use by any SIMPROCESS model. **Import for Model** imports a background graphic only for the currently active SIMPROCESS model. **Import for Model** is disabled if no model is open or the active model has not been saved and given a name.

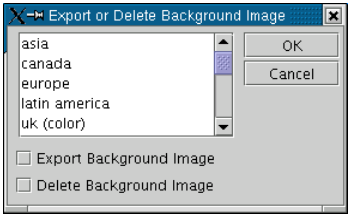


Selecting the **Import Image** or **Import for Model** buttons will open the **Import Background Image** dialog.



Select the **Browse** button, and choose a graphics file. Enter a name in the **Background Name** field. This is the name that will display in the list of available backgrounds and must be unique. Select **OK** to import the graphics file for use in SIMPROCESS.

Other features available from the **Manage Background Images** dialog can be accessed by selecting **Manage Images**, which opens the **Export or Delete Background Image** dialog.

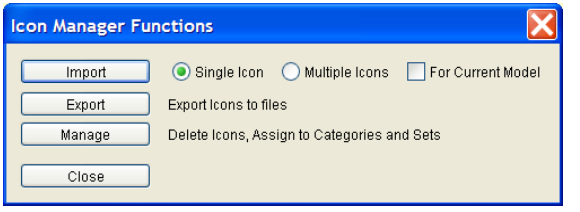


This dialog allows exporting any of the available backgrounds to external graphics files, including those provided with SIMPROCESS. In addition, it will allow deletion of any imported background images. Note that background graphics imported for the currently active model will have ** (a pair of asterisks) before the name.

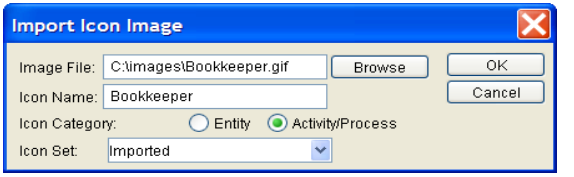
Activity, Process, and Entity Images

Use the Icon Manager (**Tools/Icon Manager**) to import a graphics file for use as a Process, Activity, or Entity.

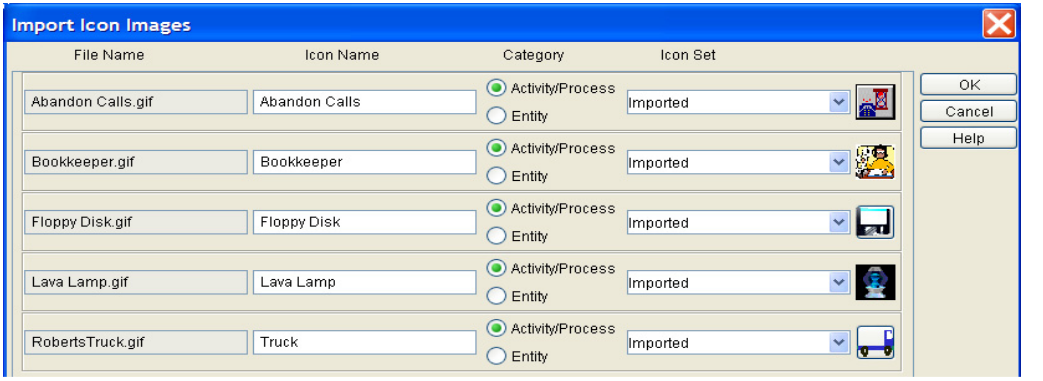
The **Icon Manager** is used to import, export, and manage image files. A single image file can be imported for use as an icon, or multiple files (such as a directory of image files) can be imported. Select **For Current Model** to have the import apply only to the currently active SIMPROCESS model. **For Current Model** will be disabled if no model is open or if the currently active model has not been saved and given a name.



Choose **Single Icon** and click **Import** to import a single image for use as an icon. Use the **Browse** button to locate the **Image File** to import. Once selected, enter the **Icon Name** which must be unique among all icons, no matter what category or set. Select the **Icon Category** and **Icon Set**. If the **Icon Set** needed is not listed, create a new set by typing it in the **Icon Set** field. Click **OK** to finish the import.



A directory of images can be imported by choosing **Multiple Icons** and clicking **Import**. Using the **Browse** button, select the directory that contains the images to import. Only directories will be listed in the file chooser. Files may not be selected. All `.gif`, `.jpg`, and `.png` files in the directory will be imported. The **Icon Name** for each will default to the name of the file minus the extension. These names can be changed as long as they remain unique among all the standard and imported icons. An error message will appear listing the names that are not unique.



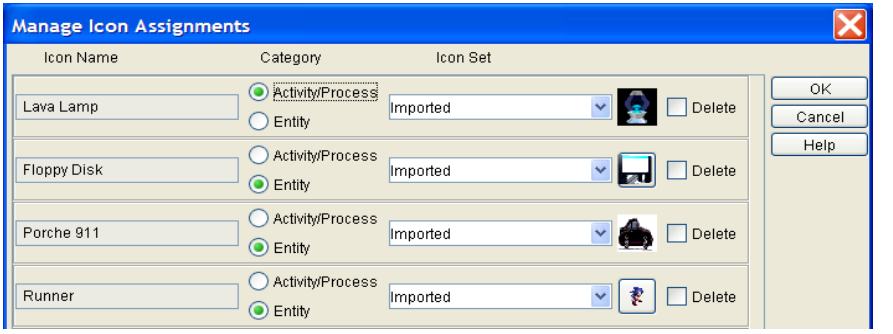
Note

When a graphic is imported into SIMPROCESS, a copy of the graphic is placed by SIMPROCESS in the `UserFiles.jar` file located in the `SIMPROCESS/SPUser` directory. If the graphic is imported for the currently active model, a copy of the graphic is placed in the `ModelImages.jar` file located in the model's directory.

Export exports images to a directory. It lists all the icons in SIMPROCESS, whether standard to SIMPROCESS or imported. The export dialog will list the **Icon Name**, **Category**, **Icon Set**,

and whether the icon is **Standard**, **Imported**, or **Model**. (**Standard** indicates the icon was included as part of the SIMPROCESS installation. **Imported** means the icon was imported for use by any SIMPROCESS model. **Model** signifies the icon was imported for use by the currently active SIMPROCESS model.) Simply select the **Export** checkbox next to the icons to export and click **OK**. Using the **Browse** button, select the directory for the exported images.

Manage brings up a dialog that lists the imported icons. This dialog changes the **Icon Name**, **Category**, **Icon Set**, or **Deletes** the icon. Icons that were imported for the currently active model will have ** (a pair of asterisks) before the name.



Post Simulation Animation

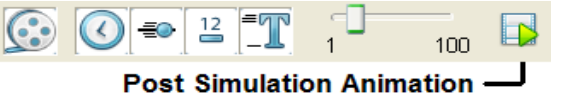
Animation is very useful in verifying and validating a model as well as communicating a model to management or customers. Normally, when turned on, animation displays while a model is simulating, which causes the simulation to slow significantly. In addition, only the animation for the current simulation time can be viewed. In other words, something in the past cannot be viewed again without restarting the simulation and waiting through the simulation to get to the point of interest.

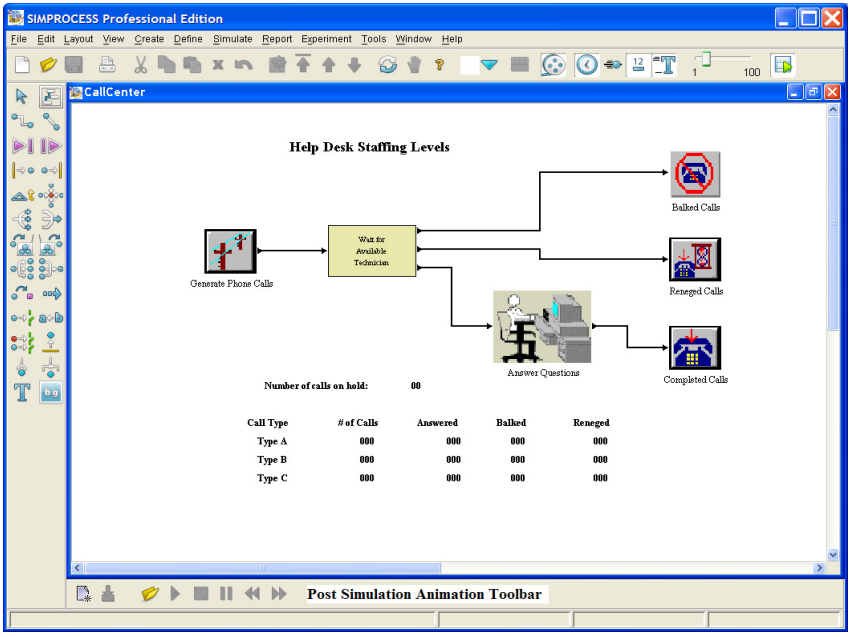
Post simulation animation displays an animation from a simulation without the simulation running. During a simulation the animation is recorded for playback. Animations can be recorded without displaying the animation during a simulation. Playback of animations that have been recorded can be paused, fast forwarded, and rewinded.

Note: Due to the addition of Connector delays and concurrent animation in SIMPROCESS Version 4.2, any animations that were recorded in a version prior to 4.2 will no longer replay. The animations must be recorded again.

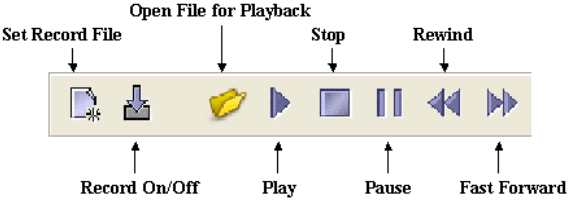
Post Simulation Animation Toolbar

Post simulation recording and playback is controlled by the post simulation animation toolbar. The post simulation animation button displays and hides the post simulation animation toolbar. The button is to the right of the **Animation Speed** slider on the System Toolbar. The toolbar displays at the bottom of the SIMPROCESS layout.





The two buttons on the left are for recording, and the remainder are for playback.



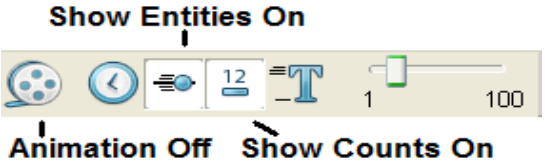
Recording an Animation

Animation events are recorded in a file for playback. In order for the **Record On/Off** button to be active, an animation event file must be set using the **Set Record File** button. The **Set Record File** button brings up a dialog where the name of the file is entered. Do not enter the path to the file. Animation event files are automatically created in the model's directory. The file name is saved with the model. If an animation event file had been previously set, the **Record On/Off** button will activate when the toolbar is displayed.

The **Record On/Off** button is a toggle button. When the button is selected, animation events

are recorded. Thus, recording can be turned on and off multiple times during a simulation.

The animation option buttons on the System Toolbar, or the **Animation Settings** dialog (**Simulate/Animation Settings** menu item) control which animation events are recorded. **Animation On**, **Show Clock**, and **Animation Speed** (slider) do not apply to recording animation events. The events recorded are determined by the status of **Show Entities**, **Show Counts**, and **Update Dynamic Labels**. If an item is selected, those type of animation events are recorded. In the example below, only the movement of entities and Activity counts would be recorded. Note that the **Animation On** button is not selected. Animation does not need to display during recording.



Warning: Animation events files can be very large. When recording counts and movement of entities, animation events for every level of the model must be recorded. Recording all that information will create very large files if recording is done for the whole simulation. The larger the model is, the larger the animation event file will be. Recording the movement of entities has the biggest impact. Recording only dynamic label events and/or Activity count events typically produces much smaller files.

Animation Playback

An animation event file of an animation that has been recorded must be opened for playback. This is done using the **Open File** button on the post simulation animation toolbar.

Important: Make sure the animation event file opened was recorded from the currently active model. The file browser will automatically open to the directory of the model. If the model has changed since the animation event file was created, delete the previous animation event files and record again.

Play

Once a file has been opened, the **Play** and **Fast Forward** buttons activate. Pressing **Play** will start the playback from the beginning of the animation event file.

Fast Forward

Pressing **Fast Forward** brings up a dialog where an amount of time to skip is entered. Note that the value entered must correspond to the **Simulation Time Units** set in the **Run Settings.** (See "Setting the Simulation Time Unit" on page 89.) That time unit will display on the dialog. If **Fast Forward** is used before **Play**, the time entered fast forwards the playback from the beginning of the simulation. Thus, if recording did not begin at the start of the simulation, it is possible that the time entered for **Fast Forward** will still be before recording began. So when **Play** is pressed, the playback begins where recording started.

Rewind

Rewind is available once playback has started. Pressing **Rewind** brings up a dialog where the amount of time to back up is entered. This time must fall within the model's **Simulation Time Units**. The playback starts over at the beginning if the time entered goes past the beginning of the playback.

Note: Both **Fast Forward** and **Rewind** have an advantage over animation during simulation. During simulation, Activity counts and dynamic labels only update when an entity enters or leaves an Activity/Process. So, when navigating through models during a run, there is normally a wait for counts and dynamic labels to display the most current values. A **Fast Forward** or **Rewind** during playback causes all counts and dynamic labels on the current level to immediately update to their values at that time.

Stop

Stop ends the playback.

Pause

When selected, the playback pauses. Press again to resume the playback.

Animation Controls

The animation buttons on the System Toolbar control what is visible during a simulation animation, and they control what is visible during animation playback. Just like during simulation animation, disabling **Show Entities** will stop the display of the movement of entities. **Show Counts** and **Update Dynamic Labels** work similarly. Remember, the **Animation On** setting has no effect on animation playback. Also, these animation settings have no effect if those particular animation events were not recorded.

CHAPTER 7

Activity-Based Costing

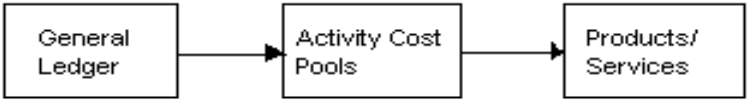
The purpose of this introduction to Activity-Based Costing (ABC) is to summarize its basic principles and describe the benefits of the integration provided with SIMPROCESS. A list of ABC references is provided in the back of the chapter for further reading.

The goal of ABC is to mimic the causal relationships among Resources, Activities, and Entities in assigning overhead costs. "The fundamental belief behind this costing approach is that cost is caused and causes of cost can be managed. The closer you can come to relating the costs to their causes, the more helpful your accounting information will be in guiding the management decisions of your business." states the *Ernst & Young Guide to Total Cost Management* (Ernst & Young, 1992).

Enterprises use Resources to conduct activities. Resources perform activities to add value to products and services. The key to understanding cost dynamics in any enterprise is modeling the relationship between activities and their causes; and the relationship between activities and costs. If cost dynamics are not modeled (which is usually the case with traditional management accounting information systems), the performance information provided is incomplete or misleading.

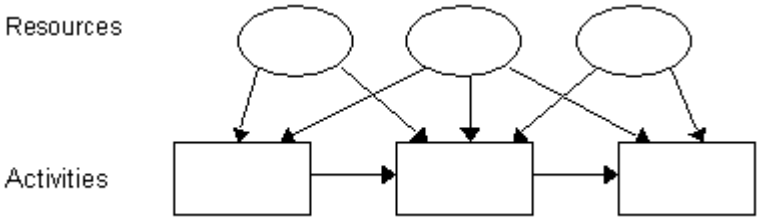
ABC and SIMPROCESS

Activity Based Costing is a technique for accumulating cost for a given cost object (i.e., product, service, customer) that represents the total and true economic Resources required or consumed by the object.



Activity Based Costing occurs in two phases. First, cost data is organized into Activity cost pools. In other words, the costs of significant activities are determined. This first phase is sometimes referred to as *Activity based Process costing*. Then, the amounts in the cost pools are assigned to products, services, or other cost objects. The second phase is referred to as *Activity based object costing*.

The architecture of SIMPROCESS provides an integrating framework for ABC. ABC embodies the concept that a business is a series of inter-related Processes, and that these Processes consist of activities that convert inputs to outputs. The modeling approach in SIMPROCESS manifests this concept and builds on it by organizing and analyzing cost information on an Activity basis.



One of the major challenges in successful implementation of ABC is finding the appropriate level of detail for the business Process analysis. The organization of business Processes is critical to reorganizing the cost data into Activity pools. The hierarchical modeling approach of SIMPROCESS facilitates this organization and accommodates varying levels of detail for ABC analysis. Another significant value of the ABC analysis in SIMPROCESS comes from the dynamic analysis of costs based on the event-driven simulation. Because SIMPROCESS tracks Resource interdependencies and captures the random nature of Processes, the cost statistics provided by SIMPROCESS are far more accurate than results obtained from static analysis.

Benefits of ABC with SIMPROCESS

Focus on Cost Drivers

One of the most important benefits of ABC is the focus it provides for estimating the key causes of costs. Executives can use these estimates to prioritize and monitor improvement efforts. For example, understanding the cost of poor quality can justify the investment in a quality program. Likewise, understanding the cost of complex or diverse products and services can help streamline the product and service offerings.

Strategic Pricing

Life cycles of product and services are becoming shorter and shorter. The up-front costs of developing, testing, and marketing are not recouped until revenue is generated. Understanding the cost trade-off between life cycle stages is critical to strategically pricing the products, i.e., understanding when the total investment in product development can be recouped is valuable information for strategic pricing. ABC with SIMPROCESS allows simulation of the Process changes during the life cycle of a product/ service for strategic or time-based pricing.

Evaluation of Capital Investments

Reengineering business Processes requires a trade-off between the benefits and costs of making Process improvement changes. Without the trade-off, executives and managers are faced with making large investment decisions based on gut feel.

How to Use ABC in SIMPROCESS

To get Process cost information from a SIMPROCESS model, first define the costs of the model's Resources and the cost periods to be analyzed. SIMPROCESS will distribute these costs to activities and to Entities as the simulation proceeds and provide extensive reporting of the results based on user-specified cost reporting periods.

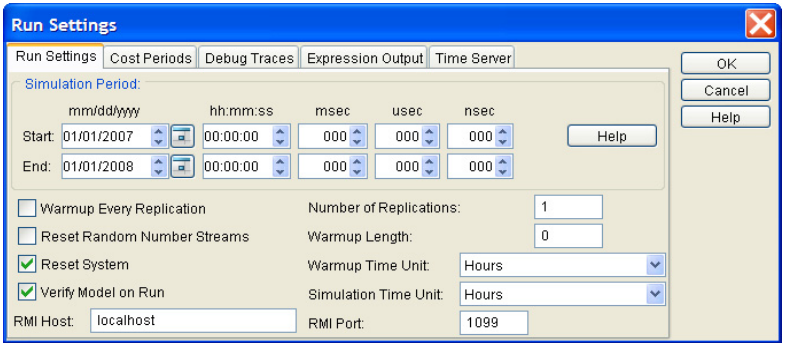
In order to provide a comprehensive cost analysis, SIMPROCESS differentiates between fixed costs and several types of variable costs that can be assigned to a Resource. SIMPROCESS allows multiple cost periods to be analyzed simultaneously and allows model level definition of costing periods. These features help to bridge the gap between an accountant's view and a manager's view of a business Process, provide an effective communication vehicle for the participants in a Process reengineering project, and make SIMPROCESS a complete business Process analysis tool.

SIMPROCESS' costing facility is very simple to use. Prior to running a simulation, define the cost periods for cost calculation purposes or accept the default cost periods, which are based on calendar quarters. Also, define costs for at least some of the Resources in the model, presumably those that represent the most significant costs in the business Process (hourly payroll, salaries, capital equipment depreciation, etc.). The following describes how to complete these two steps.

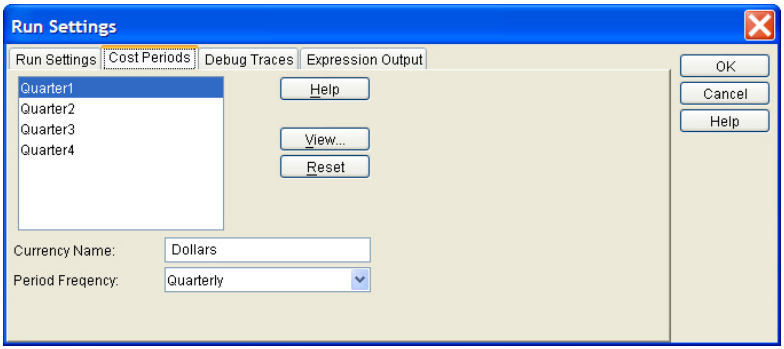
Setting Up Cost Periods

Pick the cost periods that are most suitable for the system under study. SIMPROCESS selects **Quarterly** cost periods as the default but also allows **Weekly**, **Monthly**, **Half Yearly**, and **Yearly** cost periods. The following example demonstrates how to set cost periods for the default run length.

Select **Simulation/Run Settings** from the main menu.



Then, click on the **Cost Periods** tab. This will display the **Cost Periods** definition tab as shown below.



The list in the upper left of this dialog shows the currently defined cost periods. The default periods are Quarter1, Quarter2, Quarter3, and Quarter4. At the bottom of the dialog, is the **Period Frequency** selection list with the default *Quarterly* selected. Click the down arrow button to see all of the **Period Frequencies** that SIMPROCESS offers: **Weekly**, **Monthly**, **Quarterly**, **Half Yearly**, and **Yearly**. Notice that if a new **Period Frequency** is selected, SIMPROCESS will create a new set of periods in the period list and assign each a default name (Month1, Month2,..., or Week1, Week2,...). Notice also that SIMPROCESS will automatically create and name enough cost periods to span the currently specified run length. (The simulation **Start Time** and **End Time** are set from the **Run Settings** tab.)

This dialog also sets the name of the **Currency** used on the cost reports. This is a simple label used in the reports. SIMPROCESS provides no currency conversion facilities and assumes that all cost amounts are in the same currency (e.g., Dollars or Euros).

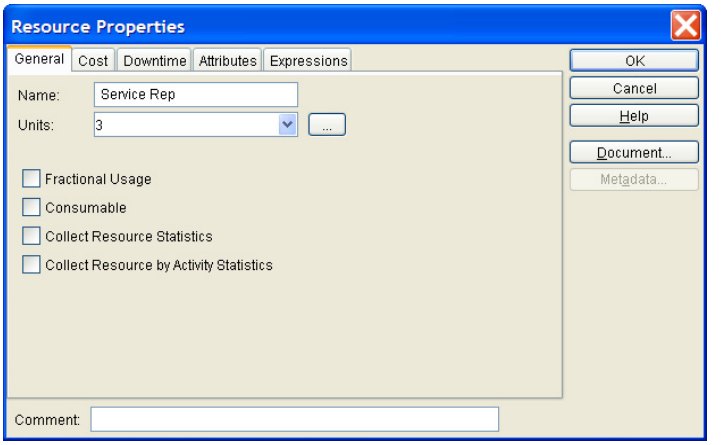
When a particular cost period is selected and the **View...** button is clicked, SIMPROCESS will display the **Cost Period** detail dialog which shows the start and end dates and times for the cost period and the name of the period. The name of each cost period can be changed to be more descriptive in the context of the cost report. For example, the cost periods could be called Spring, Summer, Fall, and Winter rather than Quarter1, Quarter2, etc. Click the **OK** button to alter the cost period name or the **Cancel** button to discard any changes.

Setting Up Resource Costs

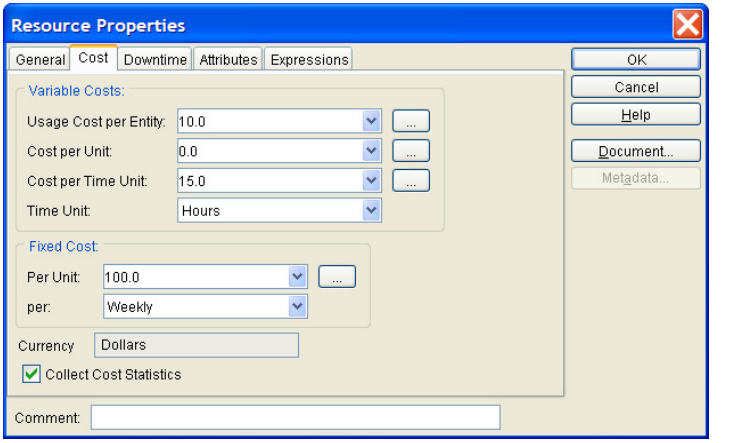
Costs can be specified for each Resource in the model. All Resources do not have to have costs specified. SIMPROCESS will generate cost reports only for those Resources that have costs assigned. Both fixed and variable costs can be assigned to non-consumable Resources, and two of the three variable costs can be assigned to consumable Resources. These costs are specified as part of defining each Resource.

Select the **Define/Resource** option from the menu bar. Then pick a previously defined Resource from the list for editing or add a new one using the **Edit** or **Add** buttons. This will display the **Resource**

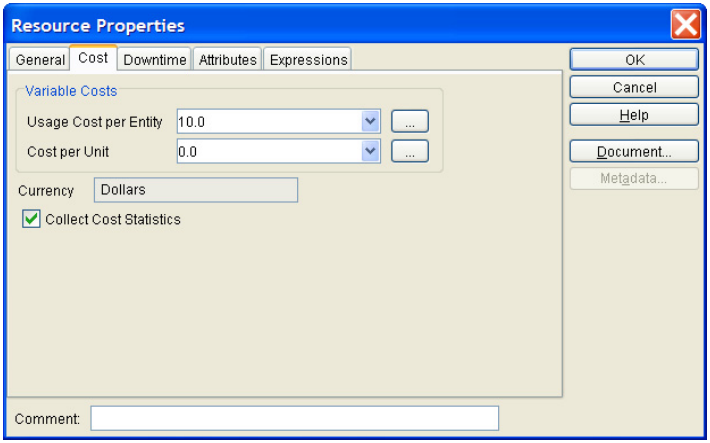
Properties dialog as shown below:



Click the **Cost** tab to display the **Resource Costs** for this Resource. Since the Resource is nonconsumable, all **Variable Costs** and the **Fixed Cost** are included.



The box at the top shows the **Variable Costs,** and the box below shows the **Fixed Cost**. Below is the **Cost** tab for a consumable Resource.



The check box at the bottom left-hand corner of the dialog, **Collect Cost Statistics**, is turned on by default whenever cost information is entered. Leave this selected. Otherwise, cost statistics will not be gathered.

Variable Costs

Three types of variable costs can be specified for non-consumable Resources:

- **Usage Cost per Entity** - This cost is applied to each Entity that is processed by the Resource. It is used to represent "flat fee" charging schemes. The same cost is assigned regardless of the amount of the Resource's units that is used or the duration of the Activity. Example: Often administrative charges or service call charges are based on this kind of charging scheme.
- **Cost Per Unit** - This cost is applied to each Entity that is Processed based only on the amount of the Resource's capacity that is used to Process the Entity. The cost is not calculated based on the time that the Activity takes to complete. Example: Fuel may be defined as a consumable Resource and cost per unit may be $1.50 per gallon. Every time a gallon of fuel is consumed, it will cost $1.50.
- **Cost per Time Unit** - This cost is calculated based on the amount of Resource capacity used and the time used. Example: Machine rental charges or hourly salary paid to employees are a common example of this type of cost.
- **Time Unit** that applies to the **Cost per Time Unit**. Defaults to **Hours**.

Fixed Cost

Fixed Cost is defined in the box below the **Variable Costs** box. Enter the fixed cost amount in the **Per Unit** value box, and select the time basis for the cost from the selection list below. Machine depreciation or fixed salaries are common examples of this type of cost. To specify the fully burdened cost of a

set of salaried employees represented by this Resource, and the cost per employee is $50,000 per year, enter 50000 in the **Per Unit** box, and select **Yearly** from the list below. Click the down arrow to the right of the list to see the available items. The list contains the same time intervals that are available for the **Cost Period Frequency**. These do not have to be the same in both places. SIMPROCESS will perform all the necessary conversions automatically.

For example, annual salaries can be specified and the simulation run with weekly cost periods. SIMPROCESS will convert the annual salary costs to weekly costs when generating the cost data. After a simulation is completed, reports of the costs are available. The total cost and the cost by period can be seen by choosing **Display Standard Report** from the **Reports** menu. These costs are divided into three categories: **Resource by Activity**, **Resource by Entity**, and **Activity by Entity**.

Cost Calculations

When a simulation is run, SIMPROCESS pauses at the end of each cost period to calculate the period costs. SIMPROCESS tracks all the activities that used the Resource and all of the types of Entities processed. For each Resource that has costs specified and that is set to calculate costs, SIMPROCESS will distribute the Resource's fixed and variable costs for the period to all of the activities that made use of the Resource during the period. This distribution is based on the amount of the available capacity used by the Activity during the period. For example, suppose that a Resource is used evenly by two activities and was busy 50% of the time for the cost period. Further, suppose that during the period each Activity processed five Entities, two of type A and three of type B. SIMPROCESS will calculate the costs for this period as follows:

1. Calculate the variable costs for each Resource based on the number of Entities Processed and the processing times as described.
2. For each of the two Resources, calculate the portion of fixed cost represented by idle time. Then calculate both the fully absorbed and capacity-based fixed costs. (In this case, the fully absorbed costs should be twice the capacity costs, since the Resource was 50% idle during the period.)
3. Add the variable costs to the fully absorbed costs and the capacity-based costs, creating two period costs for each Resource.
4. Divide the period costs for the Resource based on the usage by activities. (In this case, the period costs will be split evenly between the two activities.)

These steps are completed for all Resources in the model that are set to calculate costs. Each Activity accumulates its period costs from all of the Resources that it actually made use of during the period. Next, SIMPROCESS will calculate the Entity costs based on these Activity costs. After all Resource costs are distributed to the activities, the Activity costs are then distributed to each type of Entity Processed by the Activity, based on the total number of Entities Processed. These calculations proceed as follows:

1. The Activity determines the total number of Entities Processed for the period and the portion of this total represented by each type.
2. The Activity costs are apportioned to the Entities based on the number of each Entity type divided by the total number of Entities.

The pool of Activity cost is broken out to each Entity type based on the Entity usage of that Activity. The Activity cost is displayed in the cost report for the total number of each Entity type, not for each Entity instance. To calculate the Entity instance cost, divide the cost for that Entity type (the cost number displayed in the report) by the total number of Entities of that type processed (available in the Standard Report).

Upon completion of these calculations, SIMPROCESS resumes the simulation for the next cost period.

Note

> Get Resource Activities accumulate the costs of Resources obtained at Get Resource Activities. This is because the Resource was not actually assigned to any of the activities where processing occurred.

References

Michael R. Ostrenga, Terrence Ozan, Robert Mc Ilhattan, Marcus Harwood, *The Ernst & Young Guide to Total Cost Management*, John Wiley & Sons, New York, 1992.

Douglas Webster, *Activity Based Costing: A Tool for Reengineering the Enterprise*, Enterprise Reengineering, April/May 1995, pp. 18-23.

CHAPTER 8

Output Reports

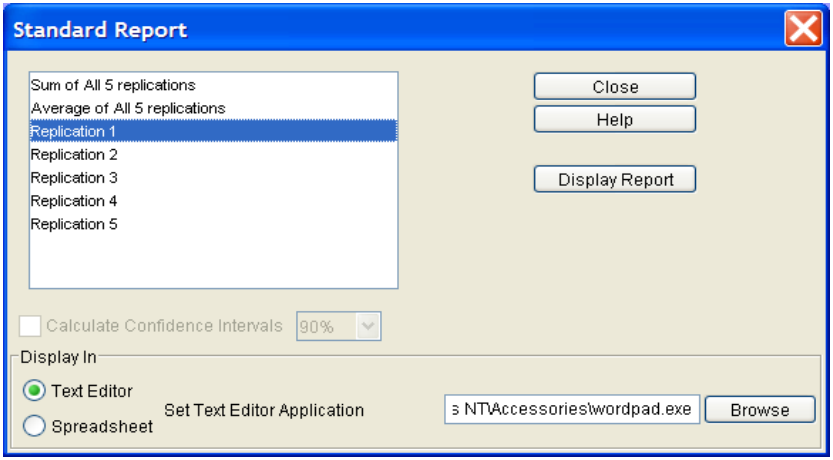
SIMPROCESS collects statistics by default for all Entities and all Resources for the Standard Report. SIMPROCESS also allows the definition of custom statistics to gather more specific information about a model. The Entity and Resource statistics gathered for the Standard Report will usually be sufficient when starting a model. As the focus of the analysis is sharpened and the model becomes detailed, custom statistics will be added to narrow in on the performance measures of most interest.

Further, real-time plots (see "Real-Time Plots," beginning on page 200) and SIMPROCESS Dashboards (see Chapter 16, "SIMPROCESS Dashboards," beginning on page 431) can be viewed, a Simulation Results file containing all the statistics gathered from the model can be exported in a tab-delimited format (see "Simulation Results File," beginning on page 583), and results can be exported to a database (see Chapter 13, "SIMPROCESS Database," beginning on page 375).

Standard Report

After the simulation run has completed, display the Standard Report to view output statistics for the model. From the **Report** menu bar, choose **Display Standard Report**.

This will open the **Display Standard Report** dialog. In the **Report Replications** list box (if the model ran for multiple replications), an individual **Replication**, the **Average of All Replications**, or the **Sum of All Replications** can be selected. Typically, for runs of multiple replications the **Average of All Replications** report is most useful. **Calculate Confidence Intervals** is activated if the **Average of All Replications** report is selected. **Calculate Confidence Intervals** allows selection of 90%, 95%, or 99% confidence intervals for each performance measure. Next, select to view the Standard Report with a **Text Editor** (Wordpad by default on Windows) or with a **Spreadsheet**. Press the **Display Report** button to open the report.



To view the Standard Report with a spreadsheet, select **Spreadsheet**, then use the **Browse** button to point to its executable, i.e., `Excel.exe`. Once the spreadsheet is open, the Standard Report data is best viewed in the left justified mode and with **AutoFit** checked for the columns.

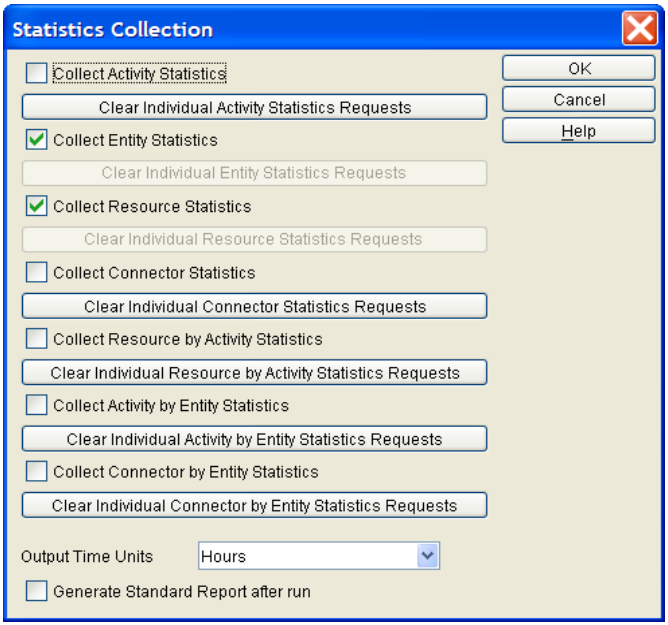
Default Performance Measures

SIMPROCESS will collect by default the following performance statistics on Entities and Resources:

- For each Entity defined in the model, Cycle Time and Count statistics are displayed.
- For each Resource defined in the model, average and maximum number of units busy is measured and shown as a percent of capacity.

- ABC reports for each Resource with cost defined in the model. The ABC reports have three sections that are broken down by cost period and total cost. These sections are **Resource by Entity**, **Resource by Activity**, and **Activity by Entity**. See Chapter 7–Activity-Based Costing, beginning on page 176 for more detail on Activity-Based Costing.

On the **Report** menu, **Define Global Statistics Collection** brings up a dialog that sets global statistics options. As stated above, **Collect Entity Statistics** and **Collect Resource Statistics** are selected. The results of the selection options are described in the following sections. The **Output Time Units** field sets the units for cycle time statistics in the Standard Report. **Generate Standard Report after run** causes the Standard Report to be generated automatically after a simulation run. This is most useful when using the Experiment Manager (page 387) or optimization (page 401). Note that Standard Reports generated automatically are not accessible from within SIMPROCESS. The file (which is located in the model's directory) must be opened separately.



Attributes are handled differently for the Standard Report. The **Standard Report** check box on the **Attribute Properties** dialog must be selected for each attribute that needs to collect statistics. The report will display either Time-weighted or Observation-based statistics depending on the option chosen. Statistics can be kept for all types of attributes except Entity Instance Attributes. Lastly, if the value of an attribute does not change during the simulation run, its statistics will all be zeroes in the Standard Report. See "User Defined Attributes," beginning on page 242 for more information on Attributes.

Custom Statistics

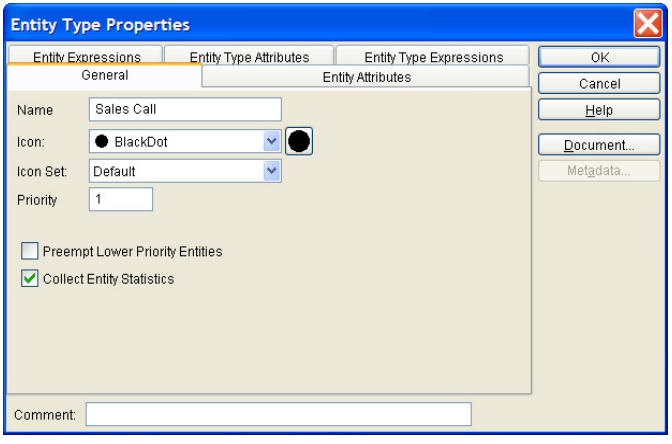
SIMPROCESS provides the ability to add custom statistics to the Standard Report for analyzing the performance of business Processes. Such performance measures as cycle time, Activity costs, and Resource utilization can be calculated by SIMPROCESS. This chapter describes the types of statistics available, and how to define, display, print, and export them.

Entity Statistics

Entity statistics provide detailed information about the numbers of Entities existing in the model during a simulation and the amount of simulation time (cycle time) that Entities require to pass through the model. SIMPROCESS provides five types of Entity statistical reports:

- Total Count
- Entity Count by State
- Entity Cycle Time by State
- Real-time Plots
- Attribute Value

Total Count, Entity Count by State, and Entity Cycle Time by State are selected either from the **Define Global Statistics Collection** dialog by choosing **Collect Entity Statistics** or by choosing **Collect Entity Statistics** when each Entity is defined. If **Collect Entity Statistics** on the **Define Global Statistics Collection** dialog is selected, then the above statistics (other than Real-time Plots and Attribute Value) will be in the Standard Report for every Entity defined. If only statistics for selected Entities are desired, then the global **Collect Entity Statistics** should not be selected, and the **Collect Entity Statistics** on the Entity Definition dialog should be selected for the desired Entities.



Total Count Statistics

These statistics show the total number of Entities that have been generated during the simulation, how many remain in the system at the end of the simulation, and how many have exited the system throughout the simulation.

Entity Count by State Statistics

These statistics present the simulation-generated Entity count statistics for selected Entity types. Statistics are time-weighted for Entity counts. These statistics show the average number of Entities in the system broken down by four states: in-process, waiting for Resource, holding for condition, and traveling.

Cycle Time by State Statistics

Cycle Time statistics present the simulation-generated cycle time statistics for selected Entity types. The cycle time calculations are based on the number of Entities that were processed at the end of the simulation. These statistics show the breakdown of the Cycle Time by state. The four states that an Entity may be in are in-process, waiting for Resource, holding for condition, and traveling.

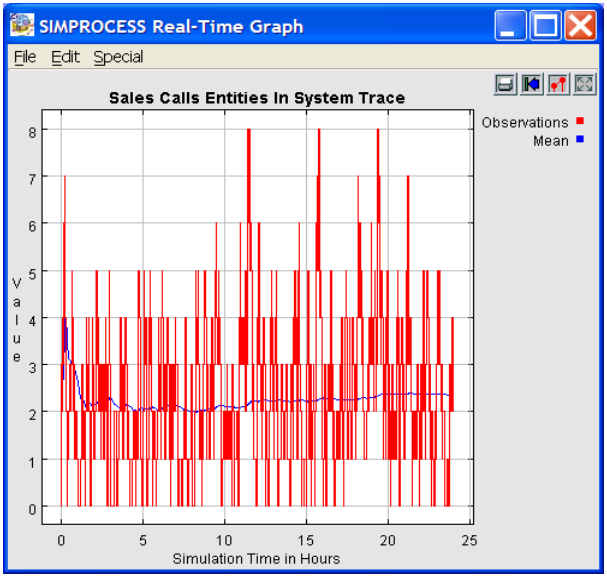
Real-time Plots

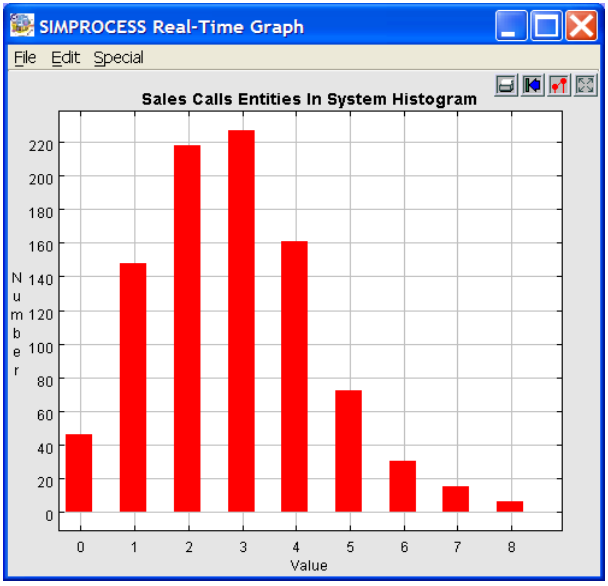
Real-time plots display statistics while the simulation is running. This may slow the simulation but real-time plots give a running view of the performance metrics during the simulation. If multiple real-time plots are selected, they will be stacked on top of each other. Real-time plots can be minimized, moved, resized, or closed while the simulation is running. Real-time plots that have been closed can be displayed again. See “Displaying Real-Time Plots” on page 203.

There are two types of real-time plots: traces and histograms. Traces display the instantaneous value of a particular statistic along with a running mean. Histograms display the number of occurrences of values of a statistic. These are grouped into value ranges called bins. The bin size is set automatically by SIMPROCESS. Traces and histograms for the same statistic do not have to be displayed together. Individual charts may be selected. Real-time plots are selected under the **Report** menu item **Define Real-Time Plots/Entities**. Plots may be customized and hidden. See “Real-Time Plots” on page 200.

Cycle Times Trace and **Cycle Times Histogram** — These reports show the individual cycle time measurements for each Entity of a given type. Charts are generated for each Entity type that is selected. The charts are updated as each Entity of the given type completes its cycle time. This occurs when the Entity is transformed or disposed in the model. The observation points on the trace are connected only to improve their visibility and are not meant to suggest continuity.

Entities in System Trace and **Entities in System Histogram** — These charts show the individual Entity count measurements (that is, the number of Entities that exist in the model) for each Entity type. Charts are generated for each Entity type that is selected. The charts are updated as each Entity of the given type is created and disposed in the model.





Wait For Resource Trace and **Wait For Resource Histogram** — These charts show the current number of Entities that are in the waiting for Resource state.

Wait For Resource Cycle Times Trace and **Wait For Resource Cycle Times Histogram** — These charts show the time spent waiting for Resources.

Hold For Condition Trace and **Hold For Condition Histogram** — These charts show the current number of Entities that are in the holding for condition state that may be associated with Activities such as Assemble, Gate, and Batch.

Hold For Condition Cycle Times Trace and **Hold For Condition Cycle Times Histogram** — These charts show the time spent holding for a condition to be met.

Entities In Process Trace and **Entities In Process Histogram** — These charts show the current number of Entities that are in the Process.

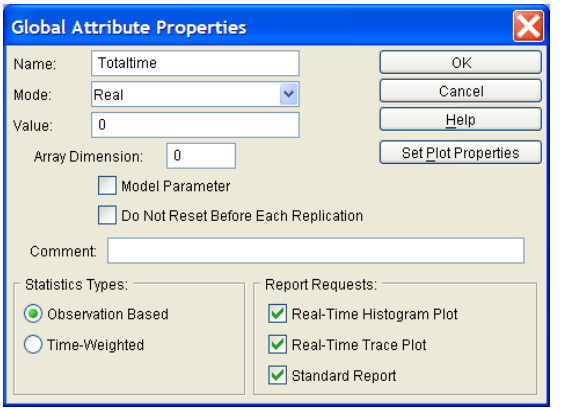
Process Cycle Times Trace and **Process Cycle Times Histogram** — These charts show the time Entities spend processing.

Entities Traveling Trace and **Entities Traveling Histogram** — These charts show the current number of Entities that are traversing Connectors.

Travel Times Trace and **Travel Times Histogram** — These charts show the time Entities spend traversing Connectors.

Attribute Value Statistics

The attribute value statistics must be specified in the dialogs where attributes themselves are defined. If the attributes are defined while Entity types are being defined, then the statistics must be selected where those attributes are defined.



Time-Weighted Average — This collects time-weighted statistics for Entity attributes.

Observation-Based Average — This collects observation-based statistics for Entity attributes.

Real-Time Histogram Plot — This displays a histogram of the attribute's values.

Real-Time Trace Plot — This displays a trace of the attribute's values.

Standard Report — Displays the results in the Standard Report.

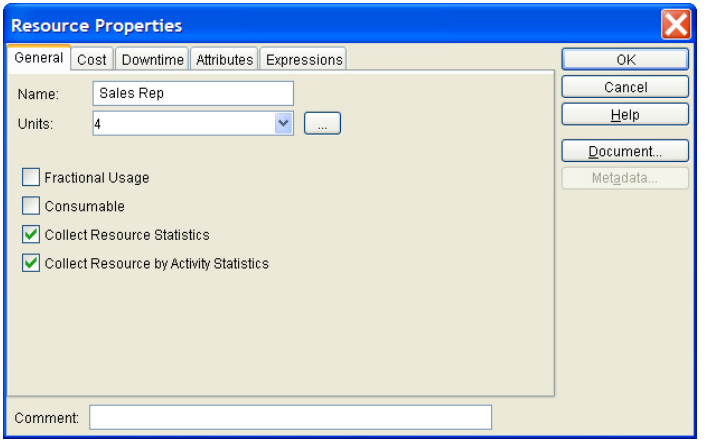
Set Plot Properties — Displays a plot properties dialog for each type of plot selected.

Resource Statistics

Resource statistics provide detailed information about the amount of time Resources spend in possible states during a simulation. SIMPROCESS provides four types of statistics which show various summaries of the state information for a Resource:

- Utilization by State Statistics
- Utilization by Activity Statistics
- Real-time Plots
- Attribute Value Statistics

Utilization by State is selected either from the **Define Global Statistics Collection** dialog by choosing **Collect Resource Statistics** or by choosing **Collect Resource Statistics** when each Resource is defined. The Utilization by State statistics will be in the Standard Report for every Resource defined if **Collect Resource Statistics** on the **Define Global Statistics Collection** dialog is selected. The global **Collect Resource Statistics** should not be selected, and the **Collect Resource Statistics** on the Resource Definition dialog should be selected if only statistics for selected Resources are desired. Similarly, Utilization by Activity is selected either from the **Define Global Statistics Collection** dialog by choosing **Collect Resource by Activity Statistics** or by choosing **Collect Resource by Activity Statistics** when each Resource is defined.



Utilization by State Statistics

These statistics present summaries of the simulation-generated statistics for the time that the number of units of the selected Resources spent in each state. The average number of units and percentages that were idle, busy, planned downtime, unplanned downtime, and reserved are shown in the Standard Report. Also included in the Standard Report are the percentages that a Resource was idle, busy, or reserved, given the Resource was available. That is, downtime (planned or unplanned) is not included. The time available is considered to be the total time for the Resource. Thus, if a Resource has no downtime defined, then the percentages for idle, busy, and reserved will be the same for the calculations including downtime and the calculations not including downtime.

Utilization by Activity Statistics

These statistics show the average number of units that were busy by Activity.

Real-time Plots

These reports display the simulation-generated instantaneous capacity allocations for each of the five Resource states. The reports present their data while the simulation is running. This may slow the simulation but they provide a running view of the Resource's behavior throughout the simulation. Real-time plots are selected under the **Report** menu item **Define Real-Time Plots/Resources**.

All report data is shown on an X-Y plot where the (horizontal) X-Axis represents simulation time and the (vertical) Y-Axis shows the Resource's units. One chart is produced for each selected Resource. Plots may be customized and hidden. See "Real-Time Plots" on page 200.

Capacity Trace and **Capacity Histogram** —These reports show the capacity of a Resource during the simulation. These plots are only useful for consumable Resources.

Units Idle Trace and **Units Idle Histogram** —These reports show the amount of a Resource's units which are left idle during the simulation.

Units Busy Trace and **Units Busy Histogram** —These reports show the amount of a Resource's units which are busy during the simulation.

Planned Downtime Trace and **Planned Downtime Histogram** —These reports show the amount of a Resource's units which are not available due to planned downtime during the simulation.

Unplanned Downtime Trace and **Unplanned Downtime Histogram** —These reports show the amount of a Resource's units which are not available due to unplanned downtime during the simulation.

Total Downtime Trace and **Total Downtime Histogram** —These reports show the amount of a Resource's units which are not available due to unplanned and planned downtime during the simulation.

Units Reserved Trace and **Units Reserved Histogram**—These reports show the amount of a Resource's units which are in reserved state during the simulation.

Attribute Value Statistics

The attribute value statistics must be specified in the dialogs where attributes themselves are defined. If the attributes are defined while Resources are being defined, then the statistics must be selected where those attributes are defined.

Time-Weighted Average — This collects time-weighted statistics for Resource attributes.

Observation-Based Average — This collects observation-based statistics for Resource attributes.

Real-Time Histogram Plot — This displays a histogram of the attribute's values.

Real-Time Trace Plot — This displays a trace of the attribute's values.

Standard Report — Displays the results in the Standard Report.

Process/Activity Statistics

Process/Activity Statistics provide detailed information about the numbers of Entities entering and leaving particular Processes/Activities during a simulation. SIMPROCESS provides seven types of Activity statistics:

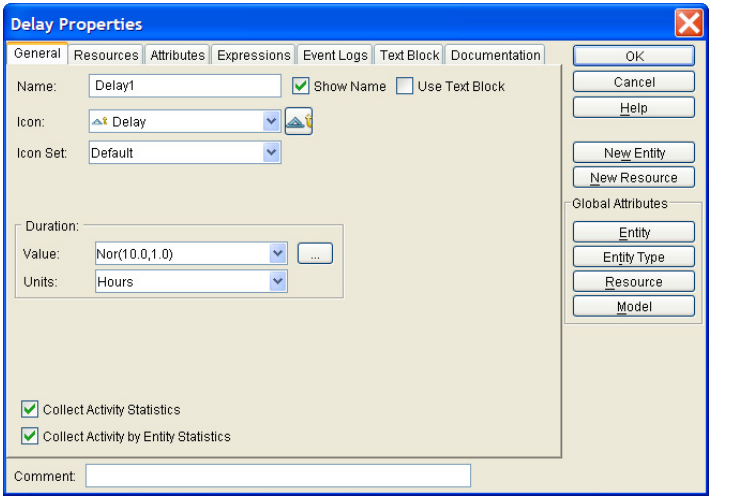
- Total Entity Counts

- Total Entity Counts by Entity
- Entity Count by State
- Entity Count by State by Entity
- Cycle Time by State
- Cycle Time by State by Entity
- Real-time Plots
- Attribute Values

The Process/Activity statistics are limited in scope to specific Processes/Activities in contrast to Entity statistics which encompass the entire model. Cycle Time by State, Total Entity Counts, and Entity Count by State are selected globally from the **Define Global Statistics Collection** dialog by choosing **Collect Activity Statistics** or locally by choosing **Collect Activity Statistics** on the individual Activity properties dialog. Activity statistics will be in the Standard Report for every Activity defined if **Collect Activity Statistics** on the **Define Global Statistics Collection** dialog is selected. The global **Collect Activity Statistics** should not be selected, and the local **Collect Activity Statistics** on the Activity properties dialog should be selected if only statistics for selected Activities are desired. Similarly, Total Entity Counts by Entity, Cycle Time by State by Entity and Entity Count by State by Entity are selected globally from the **Define Global Statistics Collection** dialog by choosing **Collect Activity by Entity Statistics** or locally by choosing **Collect Activity by Entity Statistics** on the appropriate Activity.

WARNING

Collect Activity Statistics and **Collect Activity by Entity Statistics** should NOT be selected from the Global Statistics Collection dialog for large models. This could cause memory problems and would lead to much unneeded information. It is recommended that Activity statistics always be selected at the appropriate Activity.



Entity Count Reports

These reports present the simulation-generated Entity count statistics for selected Processes/Activities.

Total Entity Count—This report shows the total number of Entities that (1) have arrived at the Process/Activity, (2) are remaining in the Process/Activity at the end of the simulation, (3) have been processed by the Process/Activity, and (4) left the Activity without processing. These can also be broken down by Entity type.

Count By Entity State—This report shows the average and maximum Entity counts broken down by Entity states, that were processed by the selected Activity. That is, how many were in the Activity, Wait For Resource, In Process, and Hold for Condition states. Entity counts for Processes will not be broken down by state. These can also be viewed by Entity type.

Cycle Time by State Statistics

These statistics present the simulation-generated cycle time statistics for the selected Process/Activity and are calculated based on the Entity counts for the selected Processes/Activities.

Cycle Time statistics present the simulation-generated cycle time statistics for Entity types that processed at the selected Activities or Processes. The cycle time calculations are based on the number of Entities that were processed at the end of the simulation. These statistics show the breakdown of the Cycle Time by state. The three states that an Entity may be in are waiting for Resource, holding for condition, and in-Process. Cycle Time will not be broken down by state for Processes. These statistics can also be broken down by Entity type.

Real-time Plots

Real-time Plots display statistics while the simulation is running. This may slow the simulation but shows a running view of the Entity count throughout the simulation. The selected charts are generated for each Process/Activity selected. The observation points are connected in trace charts to improve their visibility and are not meant to suggest continuity. See "Real-Time Plots" on page 200.

Cycle Times Trace and **Cycle Times Histogram** —These charts show the individual cycle time measurements for each Process/Activity.

Wait For Resource Cycle Times Trace and **Wait For Resource Cycle Times Histogram** —These charts show the individual wait for Resource time measurements for each Activity. These charts are not available for Processes.

Hold For Condition Cycle Times Trace and **Hold For Condition Cycle Times Histogram** —These charts show the hold for condition time measurements for each Activity. These charts are not available for Processes.

Process Cycle Times Trace and **Process Cycle Times Histogram** —This chart shows the processing time measurements for each Activity. These charts are not available for Processes.

Entity Counts Trace and **Entity Counts Histogram** —These charts show the number of Entities in each Process/Activity.

Wait For Resource Trace and **Wait For Resource Histogram** —These charts show the number of Entities waiting for Resources for each Activity. These charts are not available for Processes.

Hold For Condition Trace and **Hold For Condition Histogram** —These charts show the number of Entities holding for a condition for each Activity. These charts are not available for Processes.

Entities In Process Trace and **Entities In Process Histogram** —These charts show the number of Entities processing for each Activity.

Attribute Value Reports

The attribute value reports must be specified in the dialogs where the attributes themselves are defined. If the attributes are defined locally for a Process/Activity, then the reports must be selected where those attributes are defined.

Time Weighted Average—This collects time-weighted statistics for the selected Process/Activity attributes.

Observation Based Average — This collects observation-based statistics for the selected Process/Activity attributes.

Real-Time Histogram Plot — This displays a histogram of the attribute's values.

Real-Time Trace Plot — This displays a trace of the attribute's values.

Standard Report — Displays the results in the Standard Report.

Connector Statistics

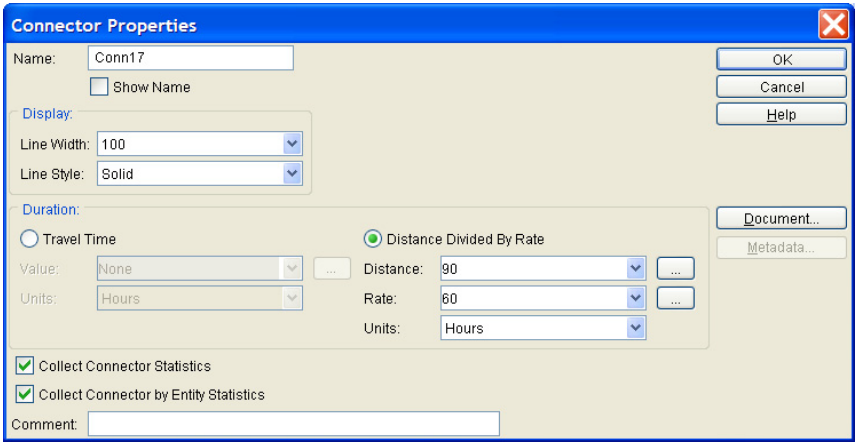
Connector Statistics provide detailed information about the numbers of Entities entering and leaving particular Connectors during a simulation. SIMPROCESS provides seven types of Connector statistics:

- Total Entity Counts
- Total Entity Counts by Entity
- Entity Count
- Entity Count by Entity
- Cycle Time
- Cycle Time by Entity
- Real-time Plots

The Connector statistics are limited in scope to specific Connectors in contrast to Entity statistics which encompass the entire model. Cycle Time, Total Entity Counts, and Entity Count are selected globally from the **Define Global Statistics Collection** dialog by choosing **Collect Connector Statistics** or locally by choosing **Collect Connector Statistics** on the individual Connector properties dialog. Connector statistics will be in the Standard Report for every Connector defined if **Collect Connector Statistics** on the **Define Global Statistics Collection** dialog is selected. The global **Collect Connector Statistics** should not be selected, and the local **Collect Connector Statistics** on the Connector properties dialog should be selected if only statistics for selected Connectors are desired. Similarly, Total Entity Counts by Entity, Cycle Time by Entity and Entity Count by Entity are selected globally from the **Define Global Statistics Collection** dialog by choosing **Collect Connector by Entity Statistics** or locally by choosing **Collect Connector by Entity Statistics** on the appropriate Connector. Connector statistics are usually only needed for Connectors with a **Duration**.

WARNING

Collect Connector Statistics and **Collect Connector by Entity Statistics** should NOT be selected from the Global Statistics Collection dialog for large models. This could cause memory problems and would lead to much unneeded information. It is recommended that Connector statistics always be selected at the appropriate Connector.



Entity Count Reports

Total Entity Count—This report shows the total number of Entities that (1) have arrived at the Connector, (2) are remaining in the Connector at the end of the simulation, and (3) have traversed the Connector. These statistics can be broken down by Entity type.

Entity Count—This report shows the average and maximum Entity counts. These can be broken down by Entity type.

Cycle Time Statistics

These statistics present the simulation-generated cycle time statistics for the selected Connector and are calculated based on the Entity counts for the selected Connectors. The cycle time calculations are based on the number of Entities that were processed at the end of the simulation. These statistics can be broken down by Entity type.

Real-time Plots

Real-time Plots display statistics while the simulation is running. The charts are generated for each Connector selected. The observation points are connected in trace charts to improve their visibility and are not meant to suggest continuity. Plots may be customized and hidden. See “Real-Time Plots” on page 200.

Cycle Times Trace and **Cycle Times Histogram** —These charts show the individual cycle time measurements for each Connector.

Entity Counts Trace and **Entity Counts Histogram** —These charts show the number of Entities in each Connector.

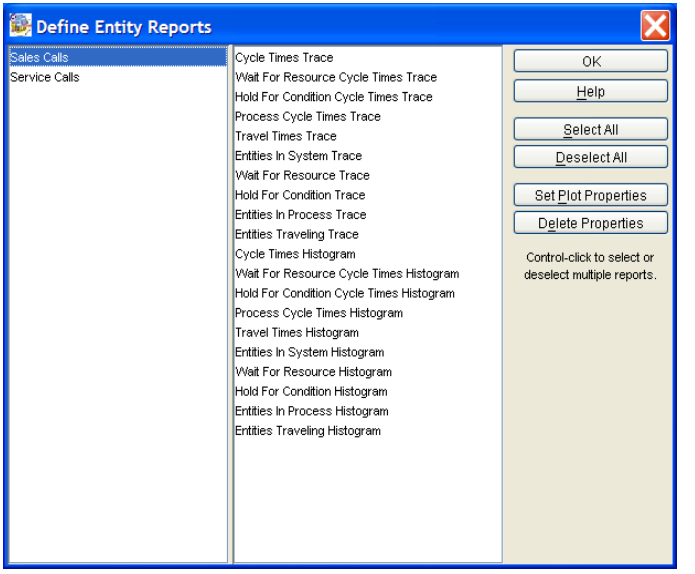
Real-Time Plots

Real-Time Plots display the change in value of statistics as the simulation runs for Entities, Resources, Activities, Processes, Connectors, Time Stamps, and Attributes.

Defining Plots

Entities, Resources, Activities, and Connectors

Plots for Entities, Resources, Activities, Processes, and Connectors are defined on the **Report** menu.



Selecting **Entities...**, **Resources...**, **Activities...**, or **Connectors...** from the **Define Real-Time Plots** menu item will bring a dialog listing the appropriate type of items defined in the model on the left, and the real-time plots available for that item on the right. Select an item on the left, then select the plots desired on the right. Multiple items can be selected on the right by holding down the Control key when selecting. The **Select All** button can be used if all plots are desired. The **Deselect All** button deselects all plots.

Once the desired plots have been selected, click **OK**. During the simulation, when the first value occurs for a particular plot, the plot appears. The plot will remain unless minimized or closed. Real-time plots

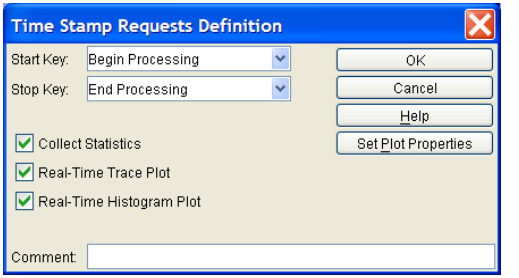
that have been closed can be displayed again.

NOTE

> Real-Time plots that have been displayed will not automatically disappear at the end of a simulation run. Each one must be closed individually. Note that all open plots will be closed when SIMPROCESS is closed.

Time Stamps

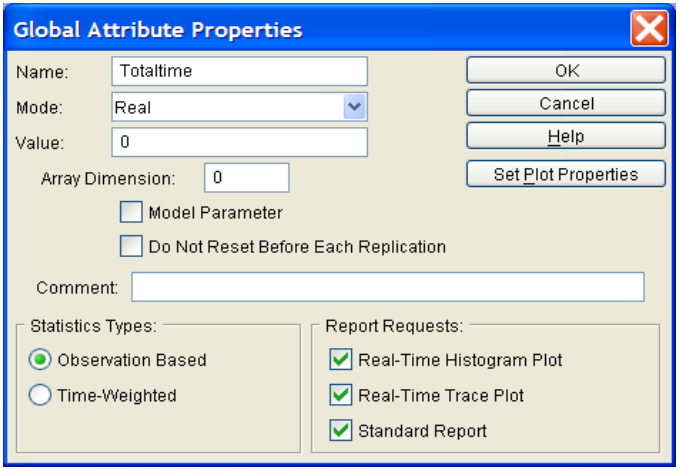
Plots for time stamps are determined when the time stamp is defined. Select **Time Stamps...** from the **Define** menu, and choose **Add** for a new time stamp or **Edit** to add plots to an existing time stamp. Enter or edit the **Start Key** and **Stop Key**.



Select **Collect Statistics** to report the statistics on the Time Stamp in the Standard Report. **Real-Time Trace Plot** causes the creation of trace plot of the data, and **Real-Time Histogram Plot** causes the creation of a histogram of the data.

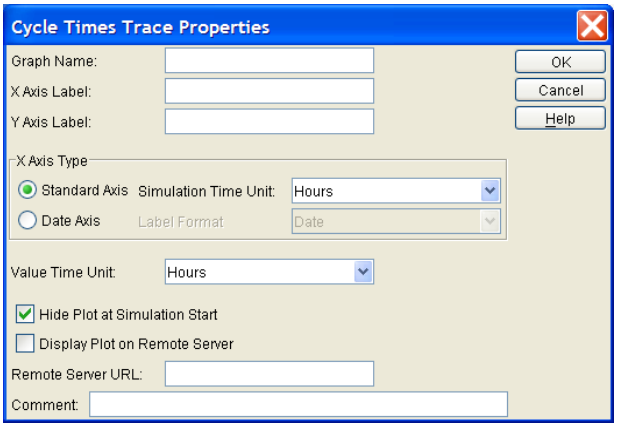
Attributes

Attribute plots are selected on the attribute definition dialog. All attribute types except Entity Instance attributes can have plots. Trace or histogram or both can be selected. Plots will be created for each item defined in the model if the attribute is a global Entity, global Resource, or global Activity attribute. For instance, if there are ten Activities/Processes in a model, and a global Activity attribute is defined with plots, then 10 sets of plots will be created since each Activity will have the attribute. Except for Model attributes, it is best to use local attributes when selecting plots for an attribute. Also, if an attribute is an array attribute, plots will be created for each member of the array.



Setting Plot Properties

Each item that can have plots has a **Set Plot Properties** button. This button sets the plot title, sets the X axis legend, sets the Y axis legend, hides the plot at the start of the simulation, and, depending on plot type, sets X axis type and the units for the X axis and Y axis. For trace plots, the X axis can either be a standard axis (default) or a date axis. A date axis displays a date and/or time instead of numbers. If the plot properties are not set, defaults will apply to the plots. The default title is the item name plus the plot name. For instance, the default title for a trace of cycle times for an Activity named Delay1 would be "Delay1 Cycle Times Trace." For a standard X axis the default units for the X axis of trace plots is the **Simulation Time Unit** selected in the Run Settings. See "Setting the Simulation Time Unit" on page 89. The default units for the Y axis of trace plots depends on the type of value being plotted. If the value is a cycle time (total, processing, wait for Resource, hold for condition, or traveling), the default unit is the **Output Time Units** selected in the **Define Global Statistics Collection** dialog. If the value is not a cycle time, then the Y axis is set according to the values plotted. Histograms follow the same rules for the X axis since the X axis plots the values in a histogram. To change any of the defaults, or to hide the plot, choose the **Set Plot Properties** button. This button will display a dialog for each plot selected.



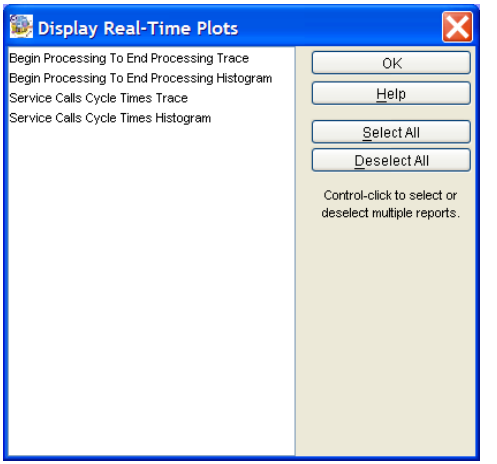
Defaults will apply if **Graph Name**, **X Axis Label**, or **Y Axis Label** are left blank. The **X Axis Type** defaults to **Standard Axis** with *Hours* selected for the **Simulation Time Unit**. When **Date Axis** is selected, **Label Format** activates. **Label Format** designates the type of date and/or time labels to display on the X axis. The possible options for **Label Format** are *Date*, *Time*, and *Date and Time*. Note that the *Time* format should only be used when the simulation length is 24 hours or less. The date and time formats adjust based on the location selected for the operating system. A United States location will display Jan 21, 2005 as 1/21/05, whereas a European location will display as 21/1/05. The plot properties default to hide the plot and to not display the plot on a remote server. The plot properties dialog will display **X Axis Type** and **Value Time Unit** based on the plot type and the value being plotted. Traces of cycle times will offer both options. All other traces will only offer the **X Axis Type** option. Histograms of cycle times will offer the **Value Time Unit** option. All other histograms will not have either option.

When plots are deselected, any properties set are lost. The properties must be reset if the plot is selected again. Also, on the **Define Real-Time Plots** dialogs for Entities, Resources, Activities, and Connectors, there is a **Delete Properties** button. This button will remove the plot properties from selected plots without deselecting the plots.

Displaying Real-Time Plots

Plots that are hidden are displayed during or after a simulation by choosing **Display Real-Time Plots** on the **Report** menu or clicking the button on the tool bar. These only become active at the beginning of a simulation run.

A dialog appears that lists all plots (hidden or not) defined in the model. All the plots are listed in the same dialog regardless of type (Entity, Resource, etc.).



The plots that are selected will display when **OK** is pressed. Once a plot is displayed it can be minimized or closed. Any plot closed can be viewed again by using **Display Real-Time Plots** from the **Report** menu or the tool bar. All plots remain available for display until the model is closed. The plots are recreated if the model is run again.

Displaying Plots Remotely

The ability to display real-time plots on a remote server is a plug-in capability that can be licensed separately from CACI. The **Display Plot on Remote Server** option must be selected, and the **Remote Server URL** must be entered.

Before the model with the remote plots starts simulation, the Java RMI Registry must be started and SPPlotServer must be started on the server where the remote plots are to appear. This requires the use of the `SPRemote.jar` and `plot.jar` files which are found in the `SPSYSTEM` directory where SIMPROCESS was installed (copy these to another system as required). To use the same system enter `rmi://localhost/` for the **Remote Server URL** field. To display the plots on a different system, change `localhost` to an appropriate value that will resolve to the Internet Protocol (IP) address of the system where the RMI Registry and SPPlotServer are located. Alternatively, just use the actual IP number.

To start the RMI Registry, a batch file or UNIX shell script can be constructed, because the RMI Registry program is required to have in its classpath the locations of files referenced by server Processes. Here are some examples of what should be contained in those files:

Windows batch file:

```
set CLASSPATH=SPRemote.jar
rmiregistry
```

UNIX shell script using the Bourne shell or a derivative:

```
CLASSPATH=SPRemote.jar
export CLASSPATH
rmiregistry
```

UNIX shell script using the C shell or a derivative:

```
setenv CLASSPATH SPRemote.jar
rmiregistry
```

Sample batch files and scripts are located in the `SPUser\SampleFiles` directory. `SPUser` is in the directory where SIMPROCESS was installed. The sample batch files and scripts are intended to be used in the SIMPROCESS installation directory.

Adjust the precise CLASSPATH value as needed, based on where the copy of `SPRemote.jar` is located and the current working directory. Once the RMI Registry program is started, SPPlotServer can then be started. When using `localhost`, enter this command from the SIMPROCESS directory on the system where SIMPROCESS is installed:

```
jre\bin\java -classpath SPSYSTEM\SPRemote.jar;SPSYSTEM\plot.jar
com.caci.remote.SPPlotServer
```

Alternatively, the `PlotServ` batch or script file in the `SPUser\SampleFiles` directory can be run. Simply copy the appropriate file to the SIMPROCESS installation directory before running.

If not using `localhost`, from the directory where SPRemote.jar and plot.jar are located, enter this command:

```
jre\bin\java -classpath SPRemote.jar;plot.jar
com.caci.remote.SPPlotServer
```

Use colons in the classpath for non-Windows systems. Once the Java RMI Registry and SPPlotServer have been started, load and run the model.

Note that remote plots are not plotted locally. Real-time plots are created either locally or remotely, but not both. Remote real-time plots cannot be hidden (even if selected in the Real-Time Plot Properties). That is, they will display as soon as simulation data is sent to the plot. Also, once a remote real-time plot has been closed, there is no way to reopen it since remote real-time plots are not in the list of plots available through the **Display Real-Time Plots** button or menu item.

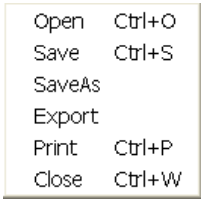
Automatic Saving of Plots

Plots are automatically saved in the `plots` directory (which is created in the model's directory) at the end of a simulation run. Only local plots are saved. All plots are saved using the name of the plot as the name of the file. When creating the file name, some special characters (:, !, @, #, $, %, ^, &, *, /, and \) in the name of the plot are replaced by underscores. Note that not all special characters are replaced, and, depending on the system and the special characters, special characters that are not replaced with underscores could cause an error during the automatic save of the plot. Trace plots have a `.trc` extension and histogram plots have an `.hst` extension. These plots will be overwritten each time the model is run. Thus, if a plot file needs to be saved, it should be renamed or moved, or the plot can be saved using the **File/Save** option. **Launch Plot Application** on the Report menu opens a plot window. Saved plots can be opened using the **File/Open** option of the plot window.

Post Plotting Options

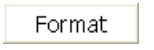
Each plot window has a menu and four buttons. These provide options to save, print, and format plots. Also, the plots have a zoom capability.

File Menu

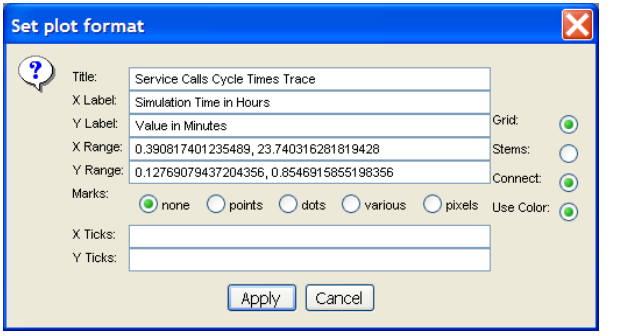


- **Open** - Opens a previously saved plot
- **Save** - Saves a plot in XML format
- **SaveAs** - Saves a previously saved plot under a new name
- **Export** - Saves the plot as an encapsulated postscript file
- **Print** - Prints the plot
- **Close** - Closes the plot window.

Edit Menu



- **Format** - Changes the format of the plot



Special Menu

- **About** - Lists information on plot developers
- **Help** - Limited information on zooming plots
- **Clear** - Erases the values plotted
- **Fill** - No effect on plot
- **Reset Axes** - Resets axes ranges to starting values

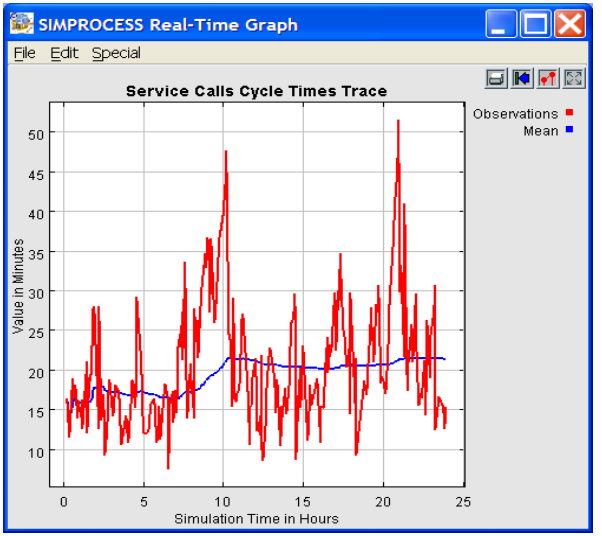
Plot Buttons

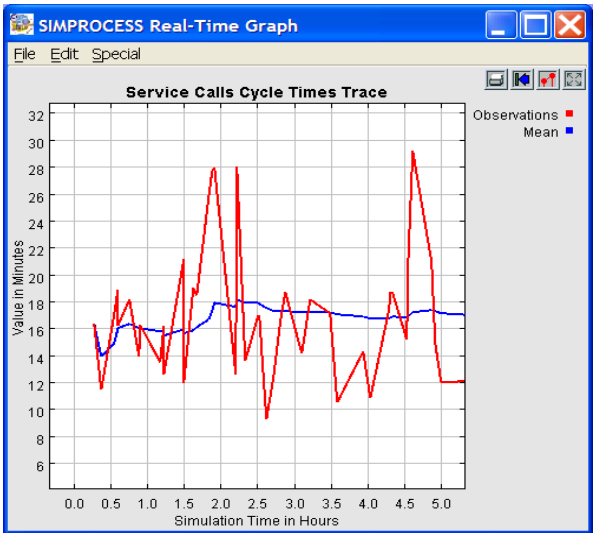
Button functions, as seen from left to right, are as follows:

- Prints the plot. (Same as **File/Print**.)
- Resets the X and Y ranges to their original values. (Same as **Special/Reset Axes**.)
- Sets the plot format. (Same as **Edit/Format**.)
- Rescales the plot to fit the data. Used after zooming to return to full view of plot.

Plot Zooming

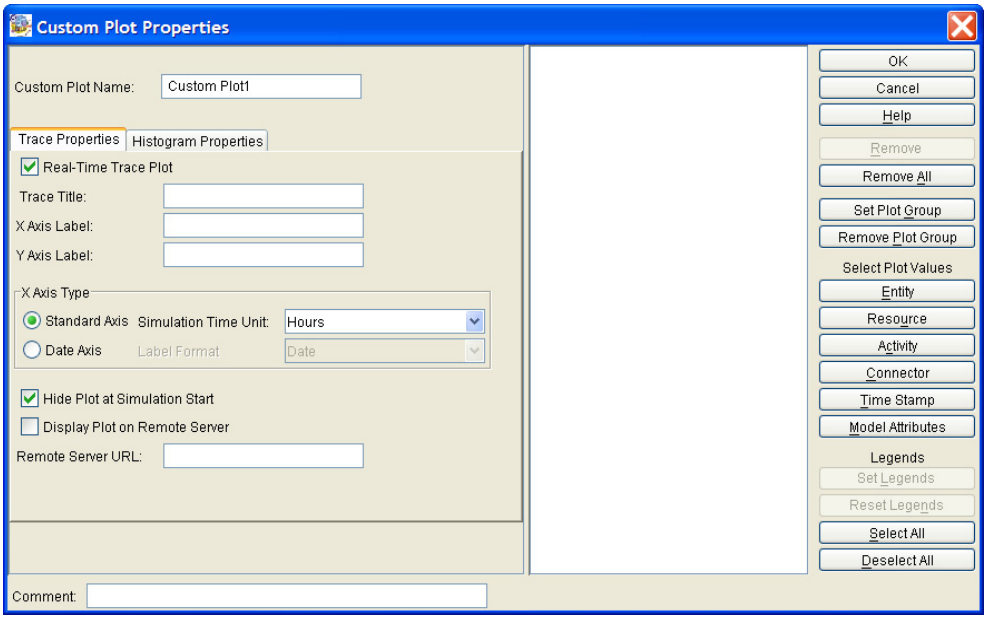
Once the simulation is complete, portions of the plot can be zoomed. To select the area for zooming, left mouse click at one corner of the area and drag over the area. When the mouse is released, that area will fill the plot. The following two plots demonstrate this. The first plot is the original plot. The second shows the plot with a portion zoomed.





Custom Plots

The real-time trace plots available from **Define Real-Time Plots** on the **Report** menu plot one value along with its mean. **Define Custom Real-Time Plots** offers the option of selecting more than one value to be on a trace and/or histogram plot. Thus, various values can be viewed in comparison with one another on the same plot. Selecting **Define Custom Real-Time Plots** brings up a dialog that lists the custom plots defined in the model. Clicking the **Add** button brings up a dialog that has the trace and histogram plot properties on the left and the list of values to plot on the right. Note that if a trace plot and histogram plot are selected, the values plotted are the same for both plots. Another custom plot must be defined if different values are to be on the trace plot and histogram plot. The plot properties on the left are the same as described on page 202.

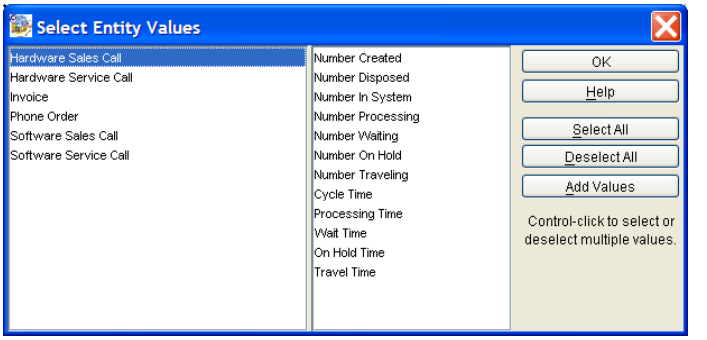


Adding Values To Custom Plot

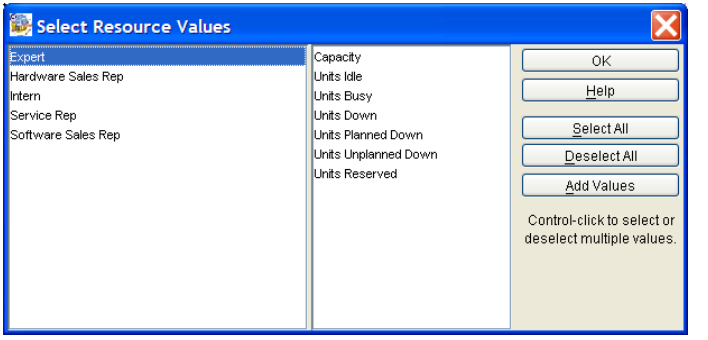
The buttons located under **Select Plot Values** of the Custom Plot Properties dialog determine which values will be plotted in the trace and/or histogram plots. The buttons are **Entity**, **Resource**, **Activity**, **Connector**, **Time Stamp**, and **Model Attributes** buttons. These buttons bring up the appropriate list of items along with the values that can be plotted.

Entity - displays a list of Entities defined in the model. Once an Entity has been selected, the values

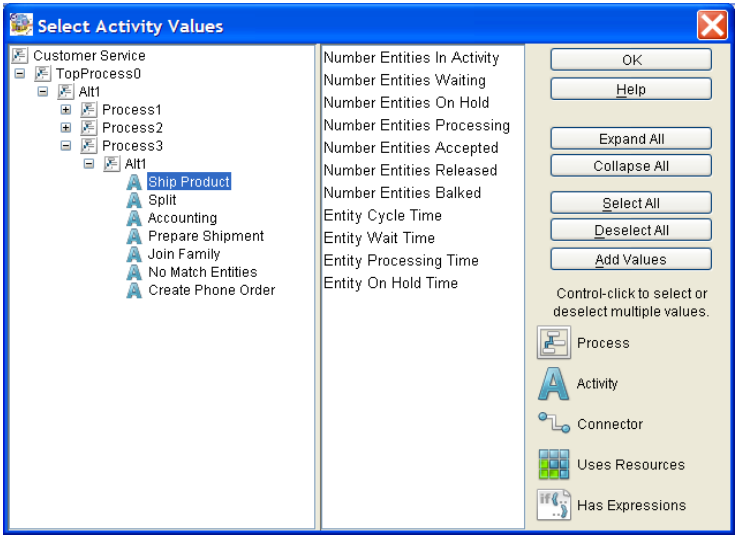
for plotting appear. The values that can be plotted are Number Created, Number Disposed, Number In System, Number Processing, Number Waiting, Number On Hold, Number Traveling, Cycle Time, Processing Time, Wait Time, On Hold Time, and Travel Time.



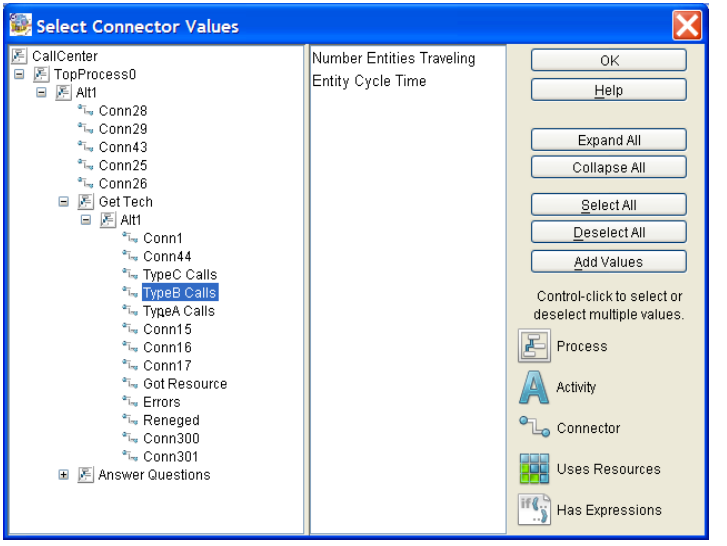
Resource - displays a list of Resources defined in the model. Once a Resource has been selected, the values available for plotting appear. The values that can be plotted are Capacity, Units Idle, Units Busy, Units Down, Units Planned Down, Units Unplanned Down, and Units Reserved.



Activity - displays a hierarchical tree of the model. Once a Process or Activity has been selected, the values available for plotting for that item appear. The values that can be plotted for Processes are Number Entities In Process and Entity Cycle Time. The values that can be plotted for Activities are Number Entities In Activity, Number Entities Waiting, Number Entities On Hold, Number Entities Processing, Number Entities Accepted, Number Entities Released, Number Entities Balked, Entity Cycle Time, Entity Wait Time, Entity Processing Time, and Entity On Hold Time.

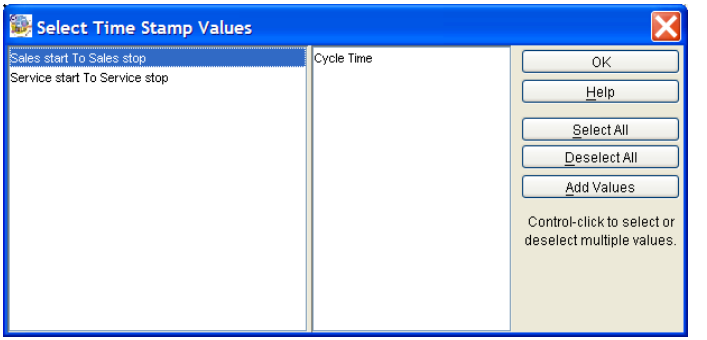


Connector - displays a hierarchical tree of the model displaying only Processes, Process Alternatives and Connectors. Once a Connector has been selected, the values available for plotting for that item appear. The values that can be plotted for Connectors are Number Entities Traveling and Entity Cycle Time.

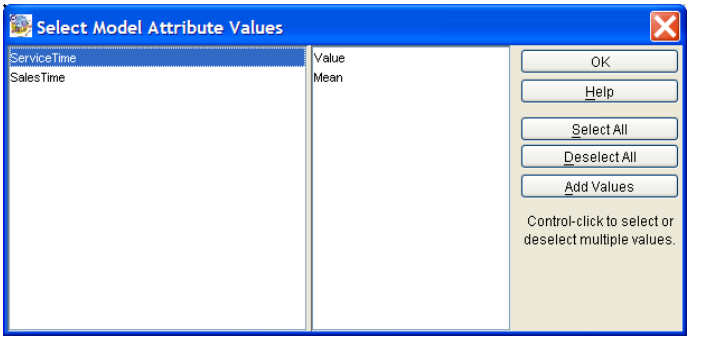


Time Stamp - displays the Time Stamps defined in the model. Once a Time Stamp has been selected,

the only value available for plotting is Cycle Time.



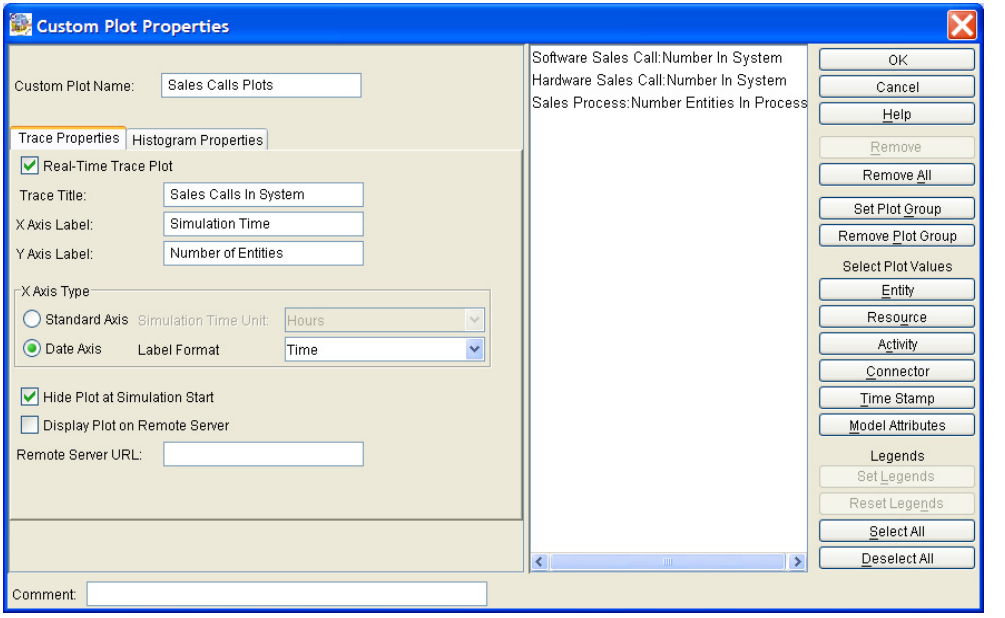
Model Attributes - displays a list of the **Integer** and **Real** Model Attributes defined in the model. Array attributes are listed by element. Once an attribute has been selected, the values available for plotting appear for that attribute. The values that can be plotted are the Value of the attribute and the Mean of the attribute. The Mean is the observation mean.

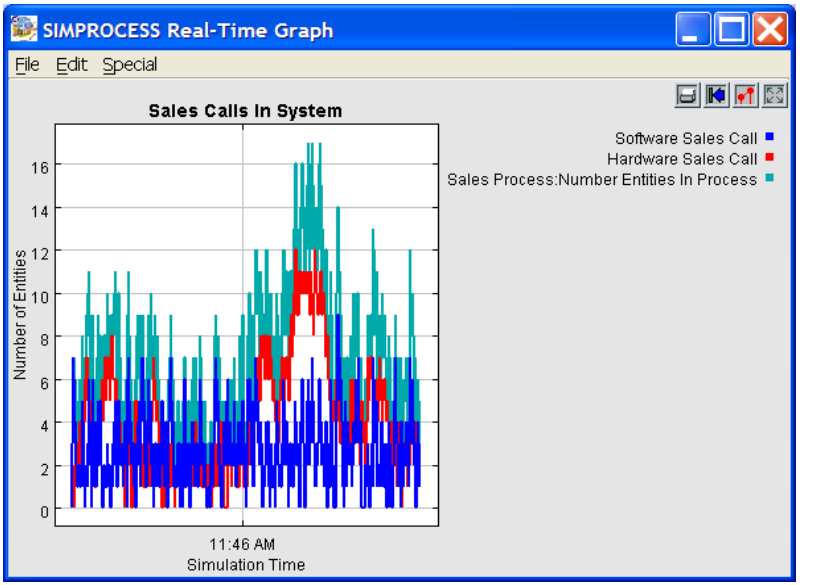


Values can be added to the plot from each type (Entity, Resource, etc.). However, adding values from different types and within types must be done with care. The units for each of the values should match. For instance a cycle time should not be plotted along with a number of Entities value (for example, Number In System). Those types of values have different units.

To add values, select the item on the left and the values desired on the right. Only one item on the left can be selected at a time. However, multiple values on the right can be selected. If all are desired, the **Select All** button can be used. Once selections are made, click the **Add Values** button. If the **Add Values** button is not clicked, no values for plotting are added. Thus, multiple values from the items on the left (Entity, Resource, etc.) can be added to the trace before clicking **OK**. Note that statistics do not have to be collected on the values selected for the values to plot.

The custom plot below plots three values: two Entity and one Activity. Hardware Sales and Software Sales are Entities. The value Entities In System is being plotted for both. Sales Process is a Process. The value Number Entities In Process is being plotted for it. All three of these values have the same units (number). Only a trace plot is defined. Following the dialog is the actual plot.





Removing Values From Custom Plot

Removing values from a custom plot is accomplished from the Custom Plot Properties dialog. There are two buttons for removing values: **Remove** and **Remove All**. The **Remove All** button clears the plot of all values. The **Remove** button clears the values that have been selected. More than one value can be selected by holding down the Control key when selecting.

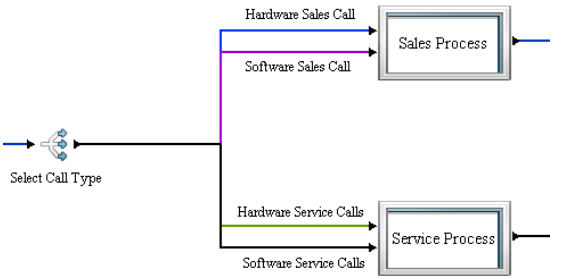
Setting and Removing Plot Group

Custom plots can be assigned to groups. Groups are based on Activities and Processes. A plot can be assigned to any group but can only belong to one group. Plot groups only apply to custom plots or Activity/Process plots from **Define Real-Time Plots/Activities** on the **Report** menu. (See “Real-Time Plots” on page 200.)

Setting Plot Group

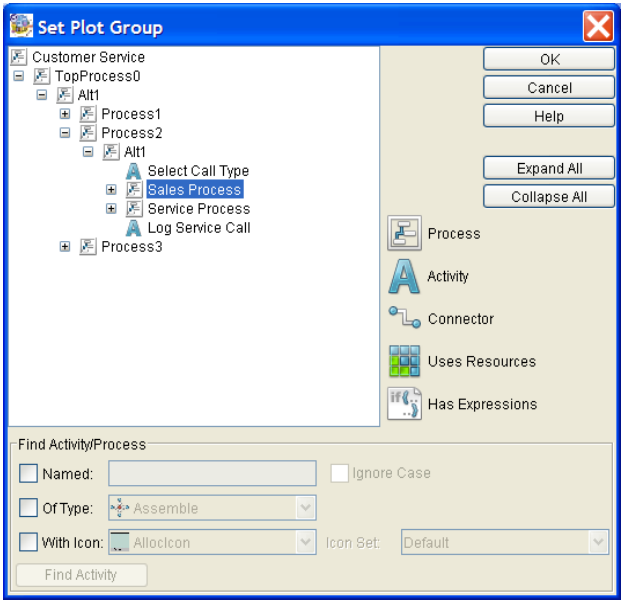
Plot groups allow custom plots to be associated with a particular Process or Activity, and they limit the number of plots in the **Display Real-Time Plots** dialog. The latter can be valuable if there are many custom plots and/or Activity plots defined in a model. **Display Real-Time Plots** on the **Report** menu or the tool bar brings up a dialog that lists all of the hidden plots in the model. This list can be restricted

by assigning custom plots to groups. For instance, below is a portion of a model that models hardware and software sales and hardware and software service. There are two subprocesses: Sales Process and Service Process.

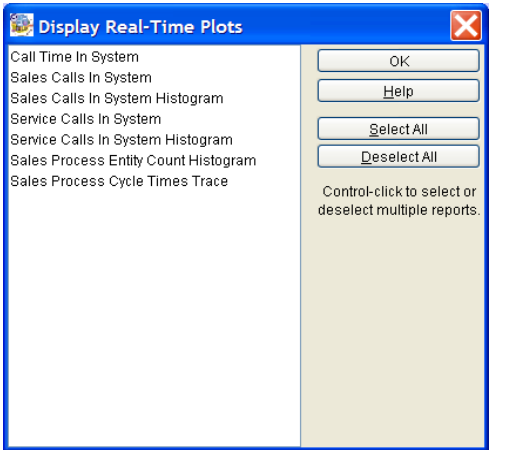


Plots can be assigned to these Processes so that, when one of the Processes is selected, only the plots assigned to its group appear when **Display Real-Time Plots** is selected.

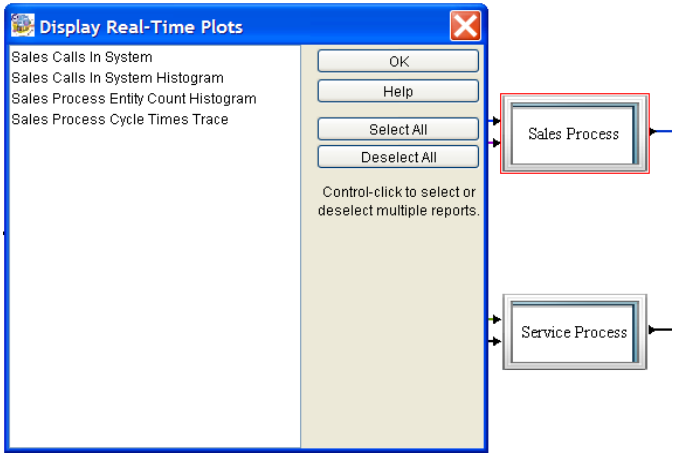
To set the plot group, click the **Set Plot Group** button on the Custom Plot Properties dialog. This opens a dialog that has the hierarchical view of the Activities and Processes in the model (similar to the Activity Browser dialog from the **Edit** menu). The item selected when **OK** is clicked is the group to which the plot is assigned. Plots cannot be assigned to the model, TopProcess, or a Process alternative. If one of those is selected when **OK** is clicked, the plot is not assigned to a group.



As an example, all the plots chosen to be hidden in the Customer Service model are shown below. This list was displayed after the model was run using the Display Real-Time Plots button on the tool bar.

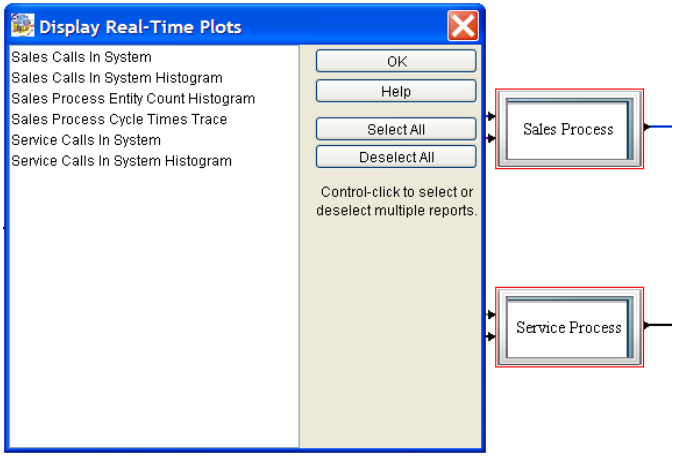


By selecting the Sales Process, this list can be restricted to the plots in the Sales Process group.



The list includes two custom plots (Sales Calls In System Trace and Sales Calls In System Histogram) and two Activity plots from **Define Real-Time Plots** on the **Report** menu (Sales Process Entity Count Histogram and Sales Process Cycle Times Trace).

Selecting the Sales and Service Processes causes the list to include plots assigned to both Processes.



Removing Plot Group

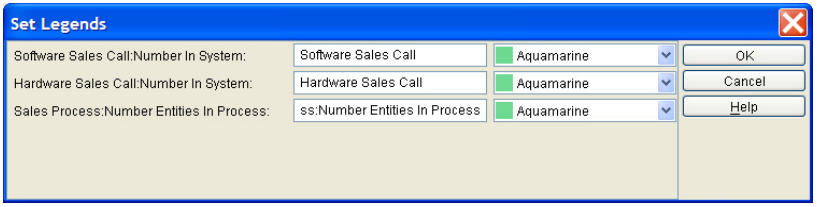
A plot can be removed from a plot group by either changing the assignment using the **Set Plot Group** button or using the **Remove Plot Group** button on the Custom Plot Properties dialog. The **Remove Plot Group** button simply removes the plot from the group, and no reassignment occurs. The button does

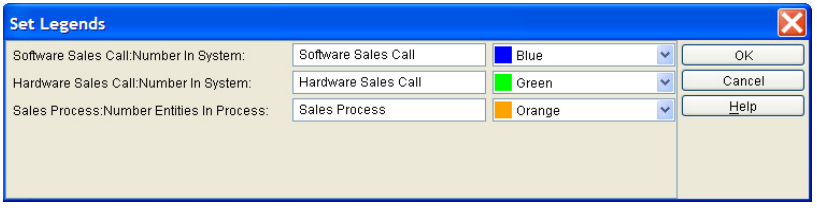
nothing if the plot is not assigned to a group.

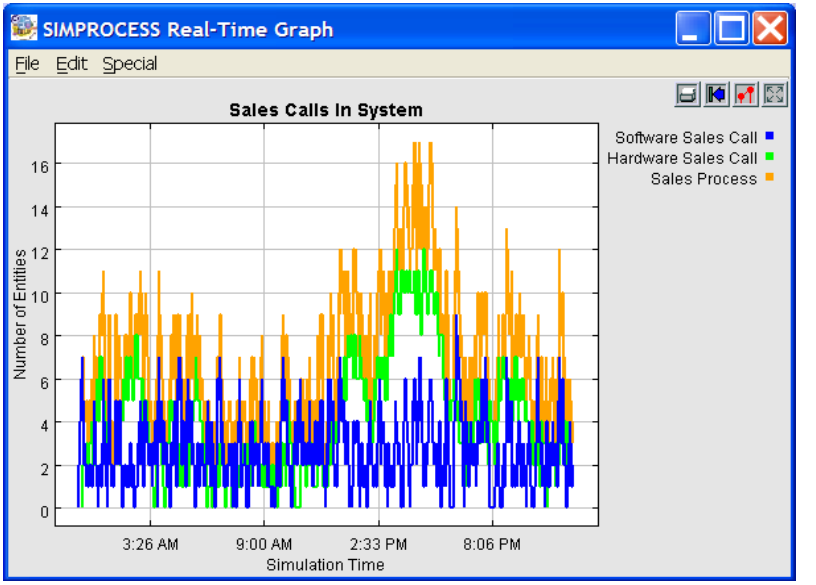
Setting Legends

The legends on custom plots default to the names of the values in the plot (for instance, Software Sales Calls:Entities In System). The **Set Legends** button allows the legend title to be changed. Also, the color of the trace line can be changed. When one or more values in the custom plot have been selected, the **Set Legends** and **Reset Legends** buttons become active. The **Select All** button selects all values in the custom plot, and the **Deselect All** button deselects all values in the custom plot.

The **Set Legends** button brings up a dialog in which the text of the legend and the color of the trace line can be set. Only the values selected will be in the dialog. Double clicking on a single value will bring up the dialog with just the options for that value. The color of the value must be set if the text of the legend is set. If not, the color will be Aquamarine, which is the first color in the color list.







The **Reset Legends** button resets the text and color of the legend to its default.

Expression Plots

Real-time Plots and Custom Plots, once defined, are updated automatically by SIMPROCESS. Also, these plots are reset at the beginning of each replication. There is no way to control when the plots are updated or reset. However, plots can be created and controlled using the SIMPROCESS Expression Language. (See Chapter 10, "Customizing a Model with Attributes and Expressions," beginning on page 237 for more information on Expressions.) Creating and controlling plots through the SIMPROCESS Expression Language allows plotting to be done across replications. Also, this capability allows replication summary statistics to be graphed.

There are five System Methods for plotting listed in "SIMPROCESS System Methods" on page 521: `CreatePlot`, `AddPlotLegend`, `ClearPlot`, `DisplayPlot`, and `PlotValue`. A discussion of these methods can be found in the section "Creating and Controlling Plots With Expressions" on page 315. Note that the demonstration model `SplitJoin.spm` that is included with SIMPROCESS has an example of Expression Plots (open model and view **Define/Model Expressions**).

Simulation Results File

The Simulation Results file is generated from the **File** menu. Select **File/Export/Simulation Results** to open the **Save Statistics** dialog. The Simulation Results file will, by default, have an `.xpt` file extension and be saved to the current model directory. This file is tab-delimited and can be opened using a text editor or spreadsheet.

The file will contain the complete statistical measures corresponding to the reports selected for the current model. This file contains raw statistical data that is displayed in the Standard and Custom Reports in a standard format that can be opened by many different applications.

For a complete listing of the format of the Simulation Results file, see "Simulation Results File," beginning on page 583

Part B
Advanced SIMPROCESS Functions and Features

The chapters in this section describe the advanced functions and features available in SIMPROCESS Professional.

CHAPTER 9

Reusable Templates and Libraries

One of the most powerful features of SIMPROCESS is the reusable Template. A Template is an Activity, hierarchical Process, Resource, or Resource Downtime that is defined and reused over and over. A Library is a collection of templates that can be saved and loaded during a modeling session. SIMPROCESS provides a standard set of templates, such as Activities, Processes, Resources, and Resource Downtimes. Templates provide the ability to set default parameters for SIMPROCESS-provided items. For example, specialized Resources such as Tellers, Loan Officers, Branch Managers can be defined in the Resource Library for Business Process Modeling in a financial services business. A Library could also contain templates that may represent competing models of the Business Processes that are being compared.

Many different Templates can be created and loaded into the system when they are needed. Customized Processes/Activities can be added to the Library Toolbar (for easy reuse) and/or added to the **Create** pull-down menu.

Library Concepts

The SIMPROCESS Template and Library feature supports the reuse and organization of the various constructs used in building models.

The development of specialized objects organized into Libraries is encouraged. Over time, the Libraries of objects will grow. With a large set of Libraries of reusable model building blocks, new models can be built faster. For example, a set of Processes (Warehouse, Manufacture, Transport) and Resources (Trucks, People, etc.) relevant to the Distribution domain can be created and saved to a Library named Distribution. These can then be used to quickly build distribution models.

Libraries built can be saved and loaded during the modeling session as they are needed. The import and export features enable the sharing of Libraries with colleagues and increases the building blocks available for model construction.

In addition to providing a repository for storing categories of modeling constructs, the Library Management facilities can be used to customize defaults for model elements that are built into SIMPROCESS (statistical distributions, Activity parameters, etc.). Processes and Activities that are used frequently can be kept on the Library Toolbar for quick access. Processes and Activities that are used less frequently can be accessed through the **Create** pull-down menu.

See "File Menu," beginning on page 20 for information on using a model's Group ID with templates.

In summary, Libraries:

- Are repositories for model building constructs created by the user
- Facilitate reuse of Processes, Activities, Resources, and Resource Downtimes
- Allow placement of Processes and Activities on the Library Toolbar and the **Create** menu
- Allow the grouping of Processes and Activities in user-defined templates
- Facilitate importing and exporting of customized model elements for use in other models or by colleagues.

Defining and Editing Templates

The **Define/Templates** pull-down menu provides access to various options for manipulating templates. The two functions available under this pull down menu are **Add** and **Library Manager**.

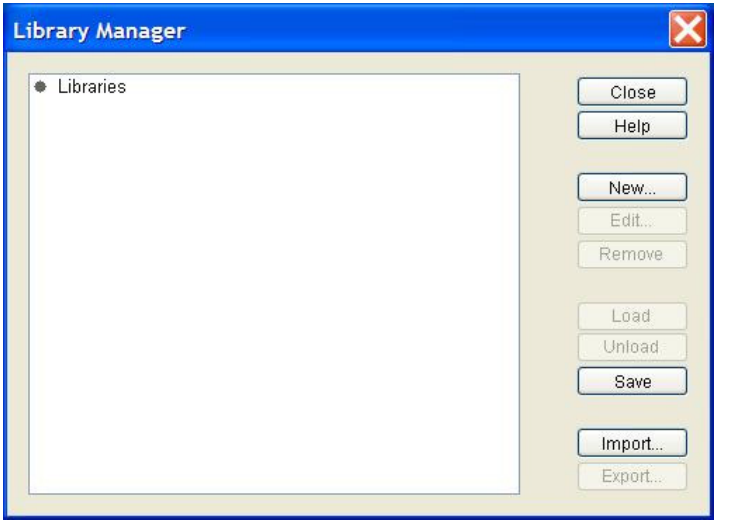
Add displays a dialog for adding a Process or Activity to a Library.

Library Manager brings up the SIMPROCESS Library Manager. The Library Manager is used to create, load, save, remove, edit, import, and export Libraries of templates

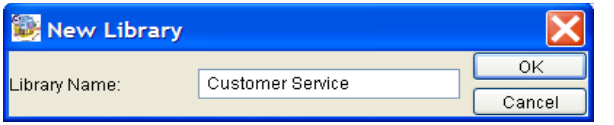
Using The Library Manager

Library Management

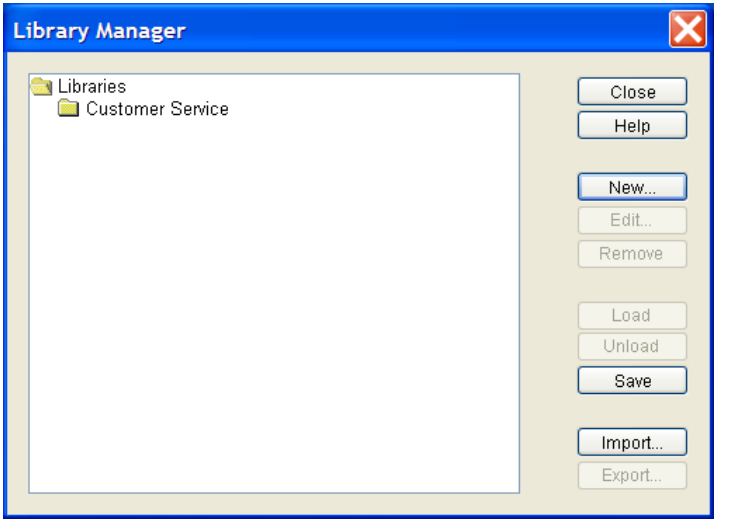
The Library Manager is the primary tool for managing templates. Before creating templates, a Library should be created. When no Libraries exist, the Library Manager is empty.



New creates a new Library in which templates can be stored. A dialog for entering a name appears.



When OK is selected, the new Library appears in the Library Manager. This new Library is empty at this point, but templates can now be stored in it.

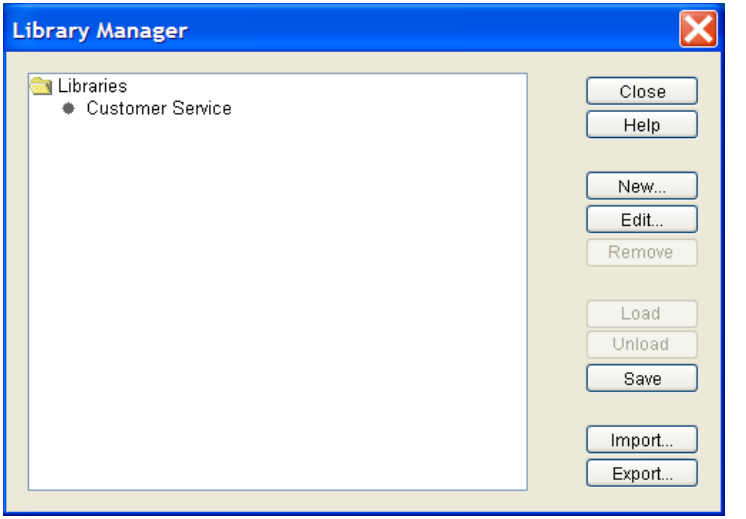


Edit allows the editing of the Library name if a Library is selected. If a Process or Activity template is selected, **Edit** allows the editing of certain template options.

Remove deletes the selected item. If a Library is selected, the Library and all templates in the Library are deleted. If a template is selected, then only that template is deleted from its Library.

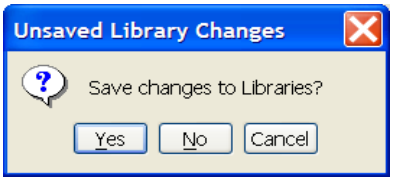
Load brings a Library that has been previously saved into the current SIMPROCESS session. The templates can then be used to build models.

All Libraries will be shown in the Library Manager. A dot by the Library means the Library has not been loaded. A folder by the Library means that it has been loaded. Simply select the desired Library and click **Load**.



Unload removes a Library from the current SIMPROCESS session. There will be a prompt to save the Library if it has not been previously saved.

Save saves a template Library for future use. When the Library Manager or SIMPROCESS is closed, there will be a prompt to save Libraries if there are Libraries that have not been saved.



Import imports a Library file that was exported by another SIMPROCESS user.

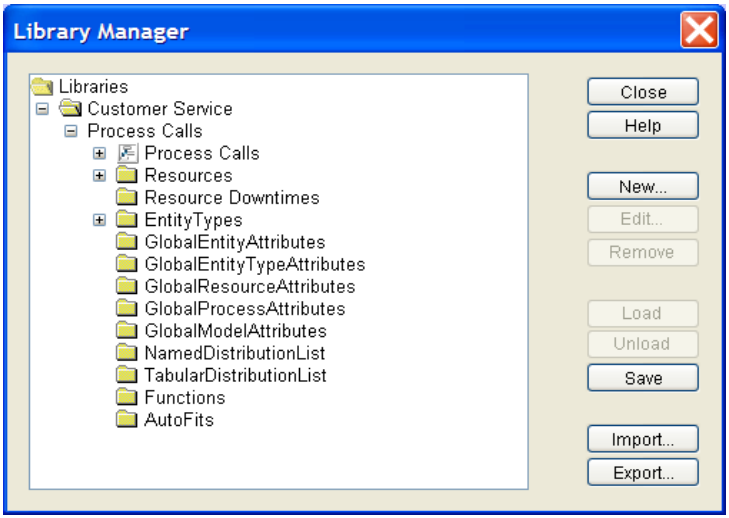
Export exports a Library file that another SIMPROCESS user can import.

Template Structure

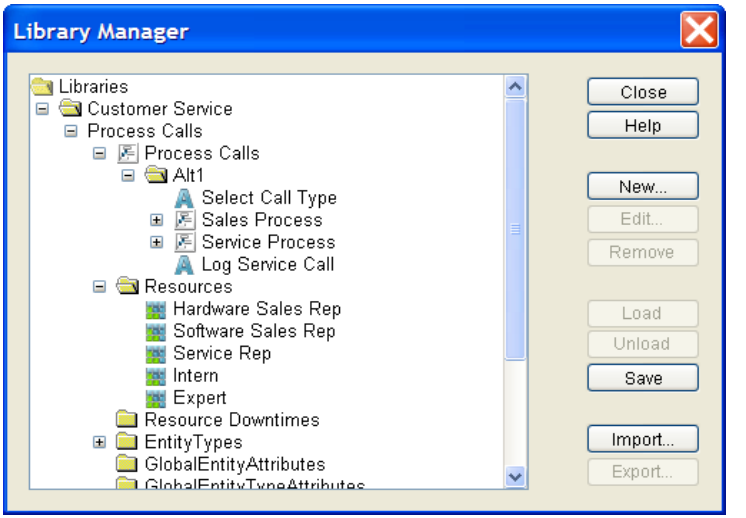
All elements of a Process or Activity template can be viewed from the Library Manager. Process templates include all the Processes and Activities that were a part of the Process. Activity templates include the Activity itself. Both types of templates contain other elements that were referenced by the Process or Activity placed in the Library. These elements include Resources, Resource Downtimes,

Entity Types, global Entity Attributes, global Entity Type Attributes, global Resource Attributes, global Activity Attributes, Model Attributes, named distributions, tabular distributions, Functions, and Auto Fits distributions. Note that code stored in a file for an Expression in a Process or Activity template or code stored in a file for a Function referenced is not included in the template. The file references are included in the template, but the template does not carry the files or their content with it.

The figure below shows a template named Process Calls in the Customer Service Library.

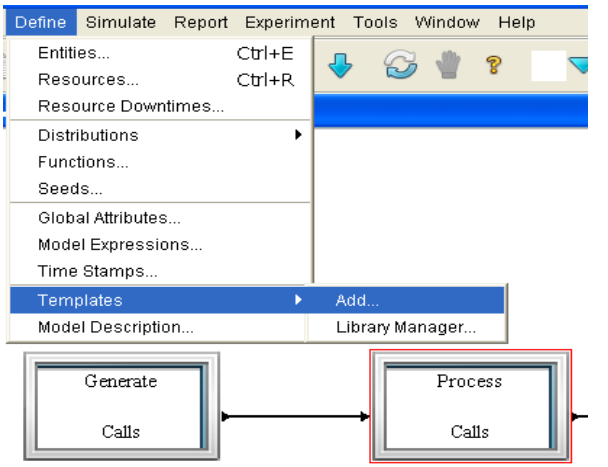


The elements with a "+" can be expanded to see the items included. Elements without a "+" were not included in the templated item. A partially expanded view is shown below.

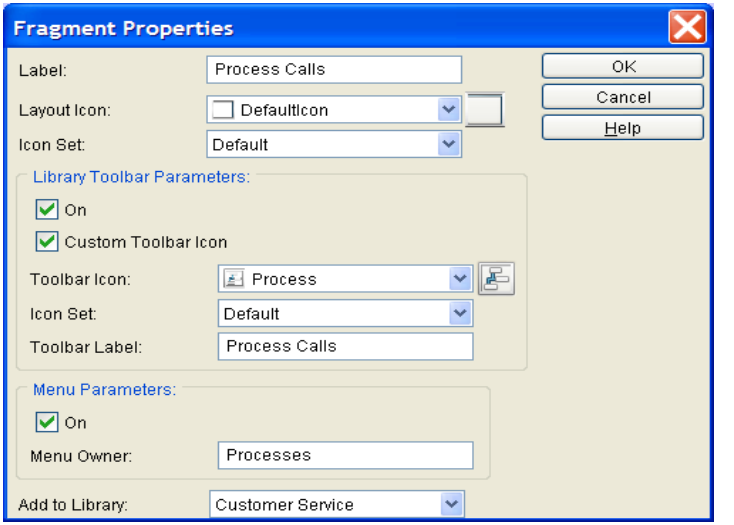


Adding a Process/Activity Template

To create a Process or Activity template, select the Process or Activity in the model, and choose **Templates/Add** from the **Define** menu. Alternatively, right mouse click on the Process or Activity and choose **Add Template** from the pop up menu.



This brings up a dialog where the template options can be set.



Label is the name of the template that will be stored in the selected Library.

Layout Icon is the icon that will display when the template is used in a model.

Library Toolbar Parameters determine the Library Toolbar settings. If **On** is checked, the template will appear on the Library Toolbar. The Library Toolbar is on the right side of the screen. If **Custom Toolbar Icon** is selected,the **Toolbar Icon** list is active.

The icon for the template on the Library Toolbar is selected from the **Toolbar Icon** list. The **Toolbar Label** is the tool tip that will appear when the mouse is over the icon.

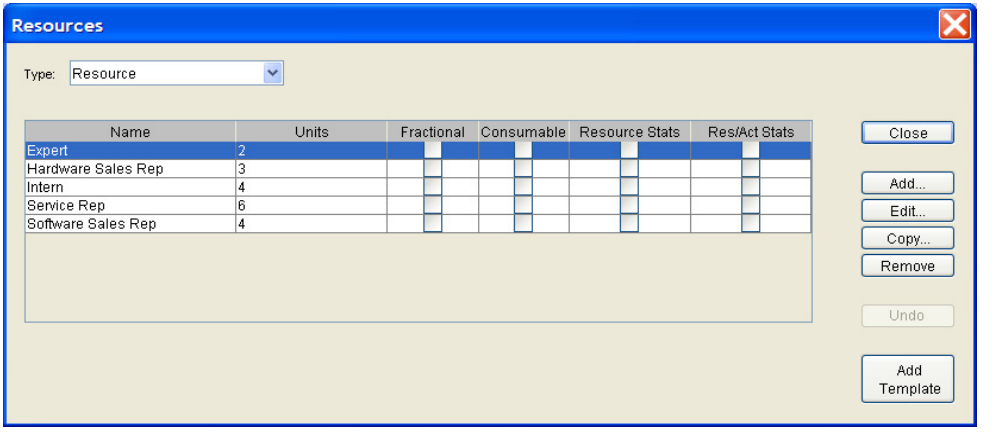
Menu Parameters determine the menu placement of the template. If **On** is selected, the template will appear on one of the **Create** sub-menus with the name from the **Label** field. **Menu Owner** sets the sub-menu for the template. One of the current sub-menus can be used or a custom menu name can be entered.

As shown above, **On** can be selected for both **Library Toolbar Parameters** and **Menu Parameters**. However, **On** must be selected for at least one of the two.

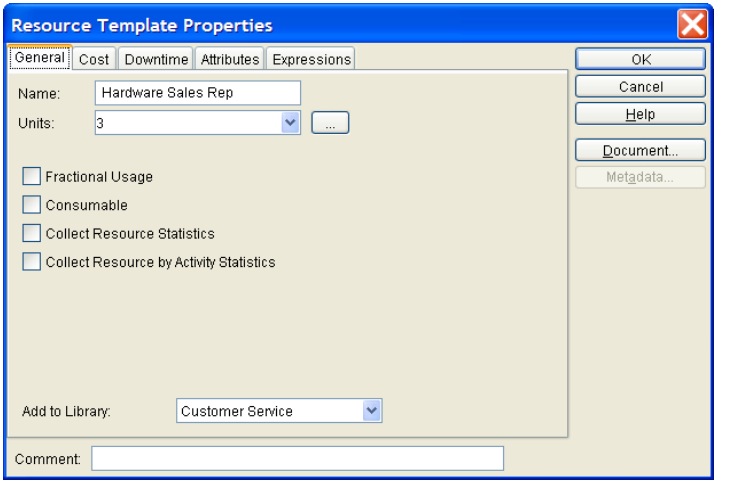
The Library that this template should be added to is selected from the **Add to Library** list. If no Library has been created, then the template will be added to a Library named *Default* (which can be renamed).

Adding Resource Templates

Resource templates are created from the Resource list. The Resource list displays all the resources defined in the model. It is accessed from **Resources** on the **Define** menu. The Resource list has an **Add Template** button.



Select the Resource and click the Add Template button. This brings up the properties of the template.

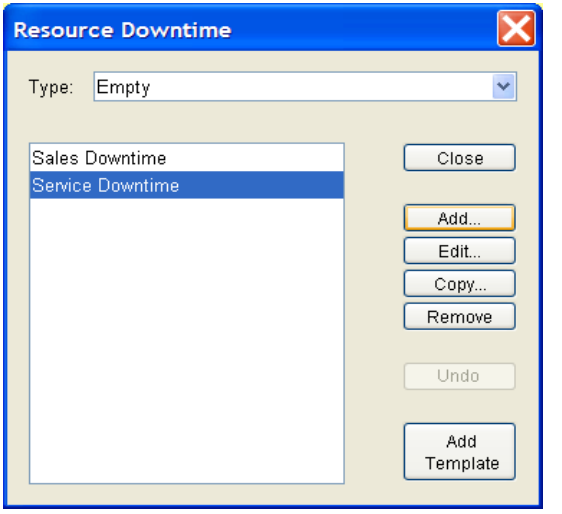


The template properties are simply the Resource properties with the **Add to Library** option added. As with the other template types, if there has not been a Library defined, the Resource template will go

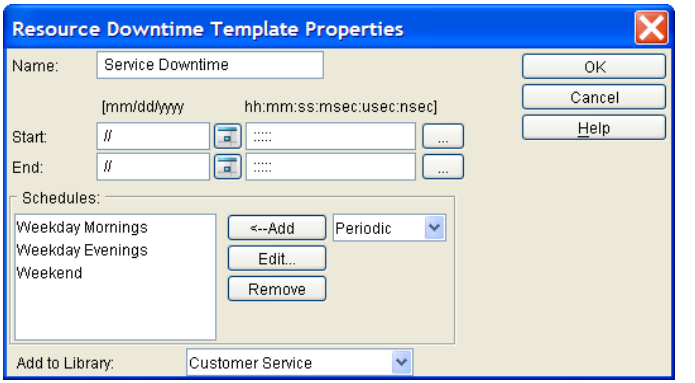
into the *Default* Library. Resource templates display in the **Type** combo box on the Resource list dialog as long as the Library in which the Resource templates reside is loaded.

Adding Resource Downtime Templates

Resource templates are created from the Resource Downtime list. The Resource Downtime list displays all the resource downtimes defined in the model. It is accessed from **Resource Downtimes** on the **Define** menu. The Resource Downtime list has an **Add Template** button.



Select the Resource Downtime and click the Add Template button. This brings up the properties of the template.



The template properties are the Resource Downtime properties with the Resource assigments removed and the **Add to Library** option added. As with the other template types, if there has not been a Library defined, the Resource Downtime template will go into the *Default* Library. Resource Downtime templates display in the **Type** combo box on the Resource Downtime list dialog as long as the Library in which the Resource Downtime templates reside is loaded.

Editing Templates

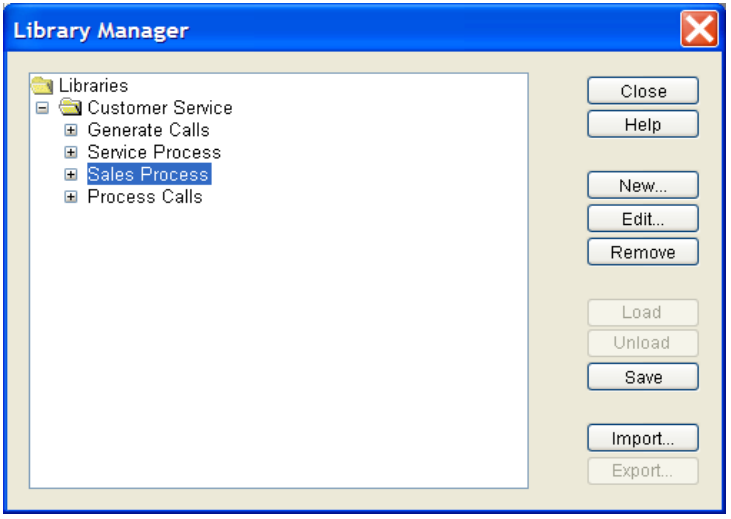
Templates cannot be edited directly from the Library Manager. However, template Library parameters can be edited from the Library Manager.

Editing Templates

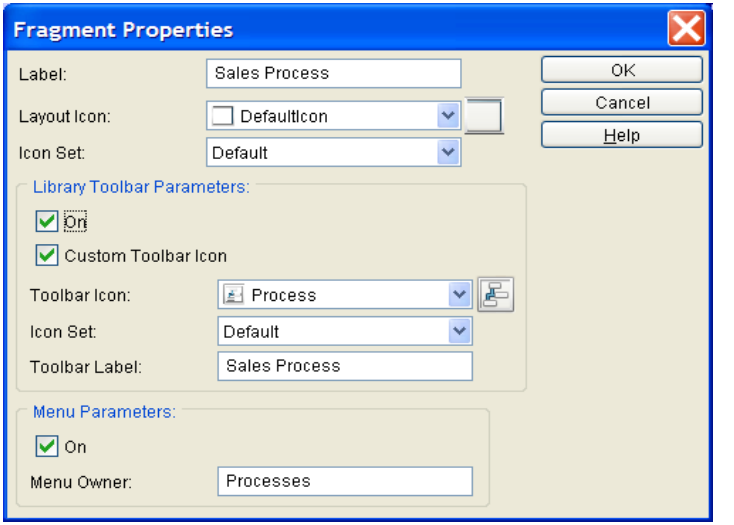
Templates can only be edited when they are part of a model. Thus, the way to change a template is to open a new model, place the template within the model, make the necessary changes, then add the changed template to the Library. If the template is added with the same name, it replaces the original.

Editing Library Parameters

To change the Library options for a template, select the template in the Library Manager and click the **Edit** button. This will bring up the same properties dialog that appeared when the template was added to its Library. The only difference is that the Library for the template cannot be changed.



Below are the template properties for *Sales Process*. Any property can be changed except the Library owner. That field is missing. To place the template in a different Library, it must be added to that Library.


Fragment Properties
Label:
Sales Process
Layout Icon:
DefaultIcon
Icon Set:
Default
OK
Cancel
Help
Library Toolbar Parameters:
On
Custom Toolbar Icon
Toolbar Icon:
Process
Icon Set:
Default
Toolbar Label:
Sales Process
Menu Parameters:
On
Menu Owner:
Processes

Advantage of Templates Over Copy/Paste

Portions of models can be copied from one model and pasted into another model. However, the copy action only copies the Activity/Connector structure. References to Entities, Resources, Resource Downtimes, user defined distributions, Functions, or Attributes within the Activities are not carried because those items may or may not exist in the model in which the paste occurs. This means all those references must be redefined in the new model. When this occurs, a dialog will appear after the paste that lists the items that have invalid references. Those items can be edited from the list.

Templates also allow portions of one model to be used in another model. However, since templates carry references to the Entities, Resources, and Attributes used, those items remain referenced in the Activities. Those references do not have to be redefined in the new model.

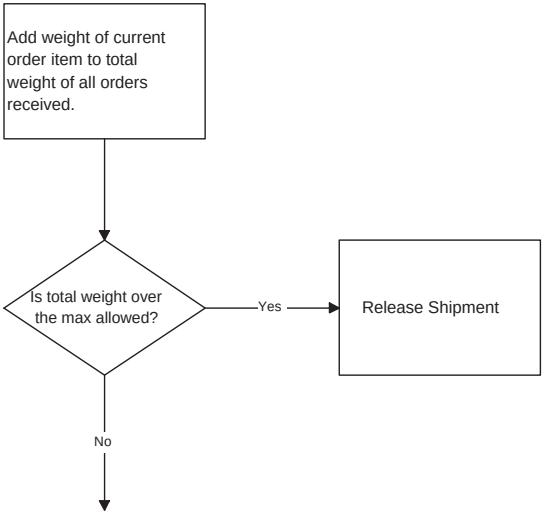
CHAPTER 10

Customizing a Model with Attributes and Expressions

SIMPROCESS provides a wide range of predefined model elements and statistical options, but every business Process is unique in some way. There will be times when flexibility is needed to model complex situations, and the built-in functions of SIMPROCESS may be inadequate. In those cases, Attributes and Expressions can be defined.

For example, a typical SIMPROCESS model for an appliance manufacturer's distribution Process might include a batch Activity where customer orders are collected for shipment. Products may be shipped on a predetermined schedule, or when the total number of pending orders reaches a certain number. The SIMPROCESS Batch Activity readily handles these scenarios with the **Quantity to Batch** and **Release Threshold** options.

But suppose the dispatching of a shipment depends on the total weight of the appliances that have been accumulated. How is this situation modeled?



Customizing reports is another area where flexibility might be needed. SIMPROCESS provides several reports that track the flow of Entities through a model. The values for how many Entities of a particular type (each customer order, for example) are processed during simulation, or the average amount of time an Entity takes to make its way through the simulation are available in the Standard Report.

But suppose the percentage of orders that are shipped by a promised delivery date (service level) is needed to measure success in attaining service goals.

Two advanced SIMPROCESS features, *Attributes* and *Expressions*, provide the ability to handle these and many other situations.

Introduction to Attributes and Expressions

Attributes

Attributes are user-defined and built-in variables of model elements whose values can change during the course of a simulation run. For example, for a Batch Process where Entity release depends on the weight of the Entities received, an Attribute is the total weight of the items accumulated in the Batch Activity.

To determine the percentage of orders processed within a specified period of time, Attributes need to track the processing time for each order, the number of orders that meet the promised delivery date, and the total number of orders processed.

Attributes may be used to:

- Alter the behavior of a Process by changing the value of an Attribute during a simulation
- Communicate information (such as Attribute values) between two Processes in a model
- Store data collected during a simulation run.

There are two categories of SIMPROCESS Attributes: built-in *System Attributes*, which SIMPROCESS automatically creates and updates, and *User Defined Attributes*, which the user creates. For example, the number of Entities generated for each Entity type (e.g., number of orders) is automatically tracked and stored in a built-in System Attribute named **`NumberCreated`**. To track an Attribute such as weight, which SIMPROCESS does not know about, an Attribute called **`applianceWeight`** could be created.

Some System Attributes can be modified by users. These are called "Get-Set" type System Attributes. Generally, these are variables that control Process parameters such as the number of Entities to batch or amount of time of the next delay. By modifying these System Attributes, the behavior of the simulation can be affected.

System Attributes that cannot be changed include those that monitor statistics, such as the number of Entities generated during the simulation. These are called "Get-Only" type System Attributes. Information on the status of a simulation, such as which Activity is processing an Entity or what type of Entity is being processed, is also available through "Get-Only" System Attributes.

See "SIMPROCESS System Attributes and Methods," beginning on page 511 for a complete list of System Attributes.

Expressions

Attributes are a powerful simulation feature when used in conjunction with SIMPROCESS Expressions. Expressions are user-written statements that SIMPROCESS executes during a simulation run. Expressions are defined at the point at which the Expression is to be evaluated; for example, at the beginning of the simulation, or at the moment an Entity (e.g., a customer order) is received by an Activity (e.g., order distribution).

In the case of the model where releasing of shipments depends on the total weight of orders such as appliances, the following could be done:

1. An Attribute called **`applianceWeight`** could be defined and its value set whenever an appliance-order Entity is generated by SIMPROCESS. The value to assign **`applianceWeight`** would be determined by checking the name of the Entity type (e.g., dishwasher-order, television-order). This information is available from the System Attribute **`Name`**.
2. When an Entity is received at the Batch Activity, the Entity's **`applianceWeight`** value would be added to the total weight of all orders waiting to be shipped (another User Attribute). The total weight would then be checked. If it exceeds a certain value, the Batch Activity would be forced to release a shipment.

One way to force a shipment to be released is to change the batch size to a value equal to the current number of Entities in the Batch Activity. These values are available in System Attributes.

This chapter describes:

- Built-in System Attributes
- User-Defined Attributes
- How to write an Expression which uses User-Defined Attributes and System Attributes.

Using Attributes in SIMPROCESS

This section contains a closer look at Attributes and how they can be used in SIMPROCESS. It starts with a look at the System Attributes built into SIMPROCESS and then goes on to a detailed discussion of User-Defined Attributes.

System Attributes

SIMPROCESS provides access to the state of a simulation through a set of built-in variables. These System Attributes provide information such as:

- The type of Entity currently in an Activity
- The number of Entities of a particular type that have been generated thus far in the simulation
- The name of the Activity holding a particular Entity
- The type of Entity being generated by a Generate Activity.

A complete list of System Attributes is given in "SIMPROCESS System Attributes and Methods," beginning on page 511. The table entries below show the Attributes accessible from Batch Activities:

Object	Name	Type	Get/ Set	Description
Batch Activities	MaxBatchSize	INTEGER	Both	Number of Entities to batch.
	MinBatchSize	INTEGER	Both	Number of Entities must be in a batch before it can be released.
	MaxWaitTime	REAL	Both	Time to wait before releasing an undersized batch.

1. The *MaxBatchSize* Attribute is an integer value representing the maximum number of Entities to batch at a Batch Activity. The current value of the Attribute can be retrieved and changed.
2. The *MinBatchSize* Attribute is an integer value containing the minimum number of Entities a Batch Activity must hold before it can release a batched Entity.
3. The Attribute *MaxWaitTime* specifies the maximum amount of time to wait before releasing the batched Entities that have met the Activity's *MinBatchSize*. The value is a real number (e.g., 1.0, 7.5, etc.) representing the time unit selected for the maximum wait time. The value of this Attribute can be retrieved and changed.

User Defined Attributes

Customizing a model begins with defining Attributes. These Attributes can represent model element Attributes that are not built into SIMPROCESS, such as Entity weight and size or skill level of a Resource.

Attributes can be defined in association with:

- Entity types or Entity instances
- Processes or Activities
- Resources
- The Model itself.

How an Attribute is defined tells SIMPROCESS whether to create an instance of that Attribute for every model element of the same type (e.g., Entities, Resources), or to just create the Attribute for a particular type of model element (customer order Entities, truck Resources). In SIMPROCESS terminology, Attributes are either *globally-defined* or *locally-defined*. Model Attributes are only globally-defined.

When an Attribute is defined globally, an instance of that Attribute is automatically created for each model element of that class. For example, if the model contains Entities of different types of appliances (refrigerators, televisions, toasters, etc.) and a weight value needs to be assigned to each Entity, a global Entity Attribute could be defined (*applianceWeight*). SIMPROCESS creates an instance of that Attribute for every Entity in the model, so every Entity has an appliance weight Attribute which can be referenced.

The only Activity concerned with weight is the Activity where Entities are batched. In this case, it makes sense to locally define an Attribute for that particular Activity. When that's done, no other Activity will have a weight Attribute automatically created for it.

Note that Attributes for different model elements can have the same name. For example, a global Attribute called *applianceWeight* could be defined for Resources. It can have a completely different meaning and data type. Global and local Attributes for the same model element cannot have the same name.

All attributes (global or local) are managed using a table similar to Entities and Resources. Changes to global attribute definitions from the table cannot be canceled. Each table can be sorted by a particular column by clicking the column header. Holding the **Shift** key while clicking the column header causes the sort to be in reverse order.

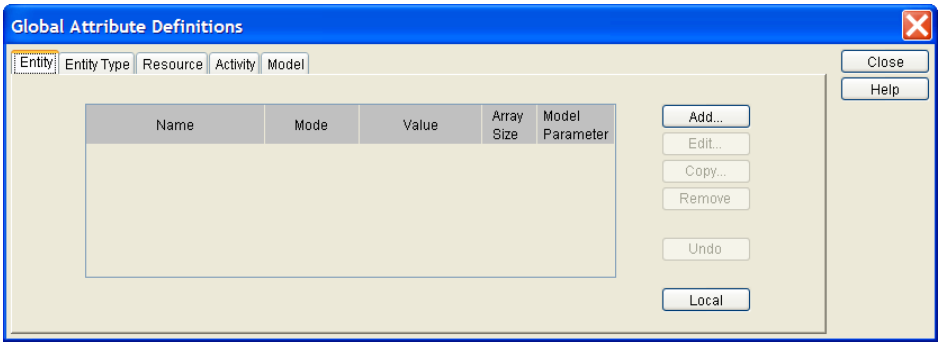
Creating a User Defined Attribute

Global Attributes can be defined from the SIMPROCESS menu or from the dialog of a model element.

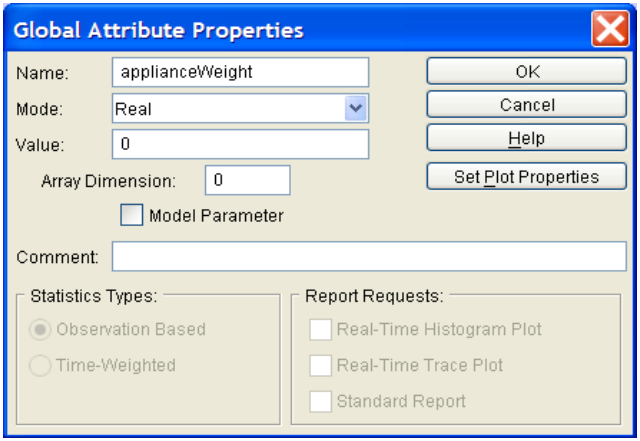
Local Attributes can only be defined from the dialog of a model element.

Globally Defining an Attribute from the Menu

To globally define an Attribute from the SIMPROCESS menu select **Global Attributes...** from the **Define** menu. The following dialog appears:



The **Global Attribute Definitions** dialog is used to add a new Attribute or to change, copy, or delete existing Attributes. There are five tabs: **Entity**, **Entity Type**, **Resource**, **Activity**, and **Model**. Each tab represents model elements for which global Attributes can be defined. Note that the **Entity** tab defines Attributes for each Entity instance created by the simulation. The originating Entity Type for the Entity instance is not considered. So every Entity instance created by the simulation will have an instance of each Attribute listed on the **Entity** tab. Attributes defined from the **Entity Type** tab are assigned to each Entity Type. That is, for all Attributes listed on the **Entity Type** tab, there is one of each Attribute created for each Entity Type that all Entity instances originating from that type can reference. Each tab shows the names of all Attributes of that type previously defined. If no Attributes have been defined, the list in each tab will be empty and the **Edit, Copy**, and **Remove** buttons will be inactive. The **Undo** button activates when an Attribute is removed. Select the **Entity** tab and click on **Add** to create a new Attribute.



In the **Attribute Properties** dialog:

Name can be anything (except as noted below), as long as the name has not been previously used for another Attribute of the same class of model element. For new Attributes, SIMPROCESS initializes the field with a default name.

Value is the default initial value of this Attribute. The value must correspond to the data type specified in the **Mode** field. For instance, 1.0 cannot be entered if the **Mode** is **Integer**. If the **Mode** is **Object**, the **Default** value is **UNDEFINED**. An **Object** Attribute's value can only be set during a simulation run. Anything entered in the **Default** field is ignored. (See **Mode** types below.)

Mode is the data type of the Attribute. Click on the arrow button to select either **Integer, Real, String, Boolean**, or **Object**:

Integer values are numbers without fractional or decimal parts.

Real values can contain fractional parts.

A **String** is any series of alphanumeric characters.

Boolean values can be either TRUE or FALSE.

An **Object** is a reference to another model element in the model, a reference for Expression Language constructs, or a reference to external Java classes. For example, during a simulation an **Object** Attribute can point to an Activity in the model.

Array Dimension allows for Attributes to be set up as an array. The default value of 0 means the Attribute is not an array. If an array dimension is provided and the user wishes to reference the Attribute in the Expression language, it must be done using an integer subscript (e.g., `myattribute[2] := value;`). The subscripted arrays are zero-based, meaning that a subscript of 0 refers to the first item in the array.

Model Parameter, when checked, means that every time the model is run, a dialog will open allowing new initial values to be entered for the Attribute. Only global, user-defined Attributes can be set as Model Parameters. If a **Comment** is entered for the Attribute, this will appear in the **Description** field of the Model Parameters dialog when the Attribute is selected.

Model Parameters can be changed during a simulation run by selecting **Change Model Parameters** from the **Simulate** menu. Note that changing the value of Model Parameters during a simulation run may or may not affect the simulation. For instance, if the Model Parameter is used to set the number of units of a Resource, changing the value of the Model Parameter will have no affect on the simulation since the units of a Resource are set at the beginning of a simulation run. However, changes to Model Parameters used to control entity flow or used for time durations will affect the simulation. If the Model Parameter is an Entity instance attribute, only Entities created after the change will reflect the change.

There is another option that does not appear on the properties dialog for global Entity Attributes. **Do Not Reset Before Each Replication** is a property of global Entity Type, Resource, Activity, and Model Attributes. If **Reset System** is selected on the **Run Settings** (page 109), all Attributes (other than Entity Attributes) are reset to their initial value before each replication. This does not happen if **Do Not Reset Before Each Replication** is selected. The Attribute maintains its current value.

Statistics Types refer to statistics collected for Attributes during a simulation run. These statistics are used in SIMPROCESS reports. Note that no statistics can be collected for Entity instance Attributes.

Observation Based and Time-Weighted refer to the way statistics are collected:

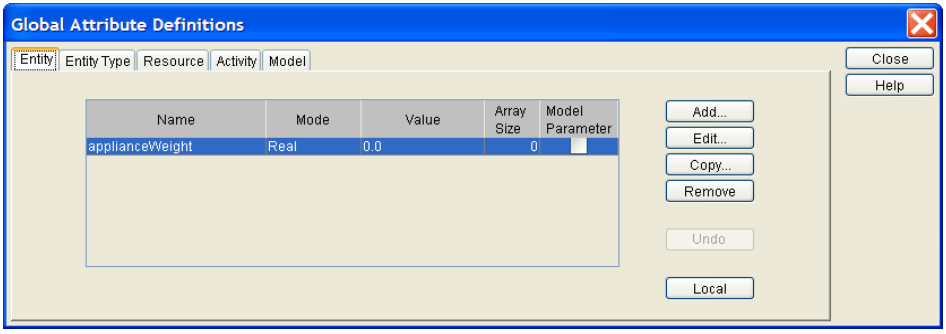
> **Observation Based** tells SIMPROCESS to collect statistical data without considering the amount of time an Attribute maintains a particular level. Each time the value of an Attribute changes, the new value is added to a running total.
>
> **Time-Weighted** provides time-weighted statistics. That is, the length of time an Attribute remains at a particular value is factored into the statistical data when the average value is calculated.

Real Time Histogram Plot tells SIMPROCESS to plot the Attribute value changes as they occur during the simulation run (Real Time Plot) using a Histogram-type graphic. The plots can be saved, printed, resized, and re-read from prior saves using the menu on the Plot dialog.

Real Time Trace Plot tells SIMPROCESS to plot the Attribute value changes as they occur during the simulation run to a trace type graphic. The trace plots can be manipulated similar to the Histogram Plots.

Standard Report tells SIMPROCESS to write the statistics to the standard report file.

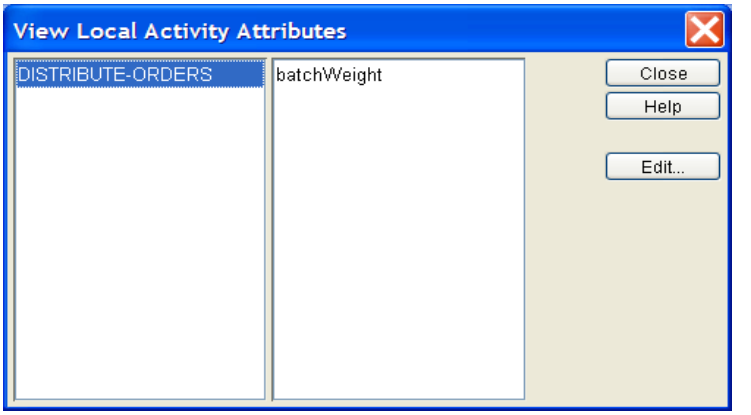
Click on **OK** to accept the options selected, or click on **Cancel** to exit without setting/resetting any options.



An existing user Attribute can be copied by selecting the Attribute in the table and then clicking on the **Copy** button. The **Global Attribute Properties** dialog is displayed with the options and defaults set to the values of the copied Attribute.

To remove an existing user Attribute, select the Attribute from the table, and then click on the **Remove** button. The **Undo** button will restore an Attribute definition that was removed.

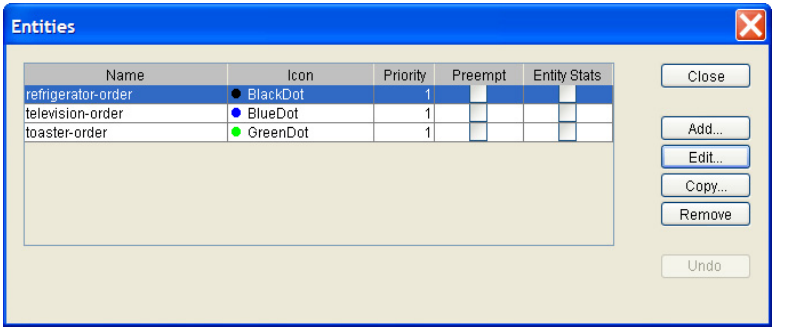
The **Local** button is on every tab except the **Model** tab (Model Attributes are only global). Selecting **Local** brings up a dialog that displays all model elements of the same type that have local Attributes. For example, the **Local** button on the **Activity** tab shows all Activities that have local Attributes defined. Selecting an item on the left displays the local Attributes for that item on the right. An item on the left can be edited by double clicking or by selecting the **Edit...** button. Note that from this dialog local Attributes cannot be defined for items that do not already have local Attributes.



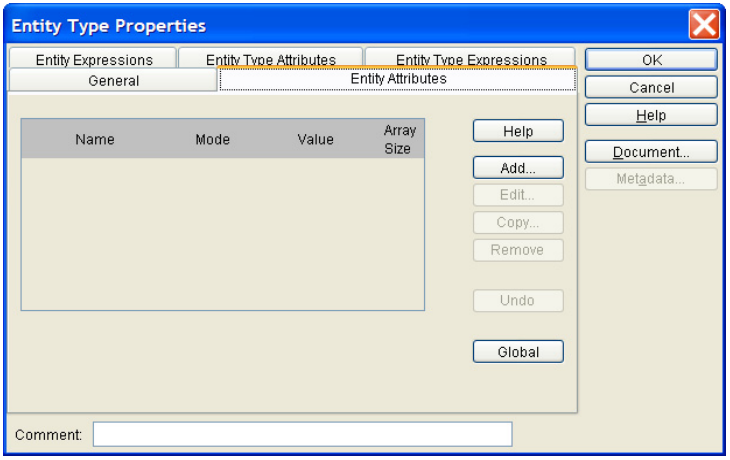
Click on **Close** when finished defining or modifying global Attributes.

Globally Defining Attributes from Dialogs

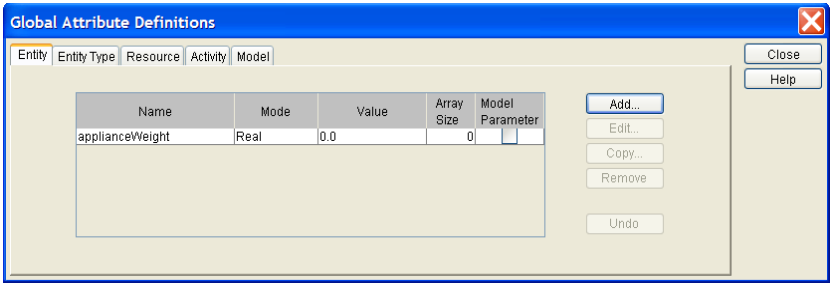
All global Attributes (other than Model Attributes) can also be accessed from the properties dialog of the appropriate model element (Entity, Resource, or Activity). For example, assume a model has three Entities defined (refrigerator-order, television-order, and toaster-order). Selecting **Entities...** from the **Define** menu, brings up the list of defined Entities.



Editing the refrigerator-order brings up the properties dialog. The image below shows the **Entity Attributes** tab selected.

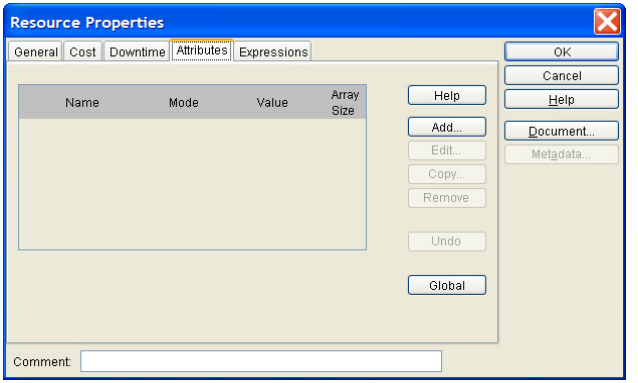


There are no local Entity Attributes defined for this Entity. The **Global** button brings up the Global Attribute Definitions dialog with the appropriate tab active. Since the **Entity Attribute** tab is selected on the Entity properties dialog, the **Entity** tab will be active on the Global Attribute Definitions dialog. Note that the **Local** button is missing since the Global Attribute Definitions dialog was opened from the properties dialog of a model element.



Defining a Local Attribute for a Model Element

A local Attribute is defined for a single model element (Entity, Resource, or Activity). Local Attributes are defined from the properties dialog of the model element. Note that Entity instance and Entity Type local Attributes are both defined from the Entity properties dialog (**Entity Attributes** and **Entity Type Attributes** tabs). The Resource and Activity properties dialog each have an **Attributes** tab. Attributes defined locally exist only for the model element in which they were defined. Local Attributes are managed in the same manner as the Global Attributes by using the **Add...**, **Edit...**, **Copy...**, and **Remove** buttons. The **Attributes** tab for Resource properties is shown below.

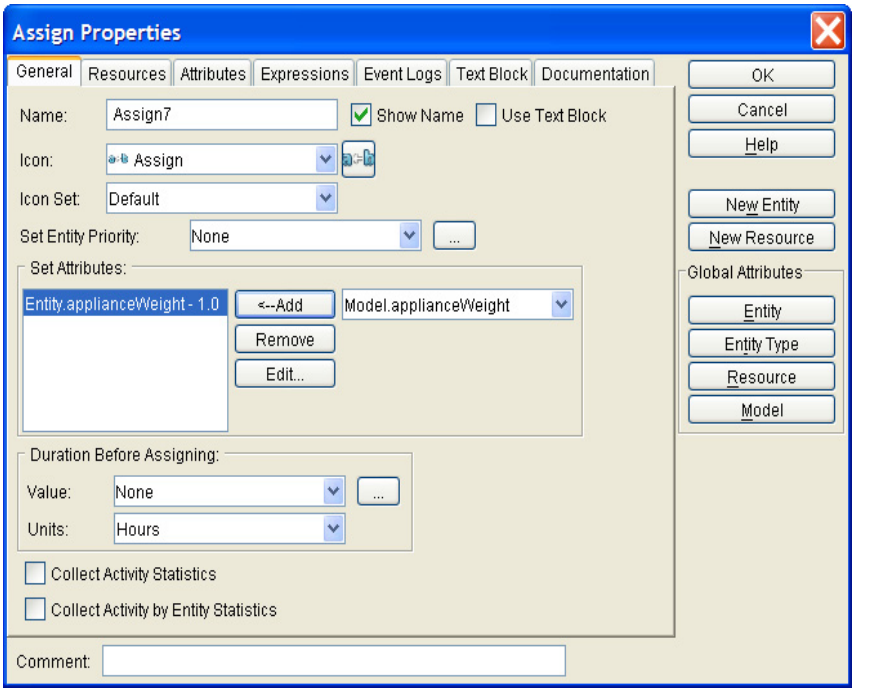

Resource Properties
General
Cost
Downtime
Attributes
Expressions
Name
Mode
Value
Array Size
Help
Add...
Edit...
Copy...
Remove
Undo
Global
OK
Cancel
Help
Document...
Metadata...
Comment:

Assign Activity

The Assign Activity can be used to assign values to globally defined Attributes and local Entity instance and Entity Type Attributes. The Assign can also change the priority of an Entity.

Changing an Attribute Value with the Assign Activity

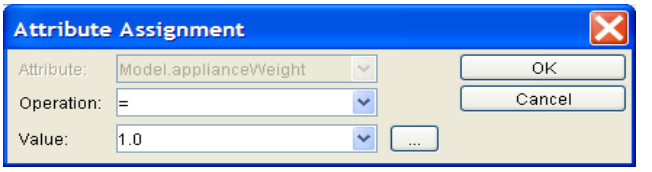
The **Set Attribute** list box of the Assign Activity is used to change the value of any global Attribute (except globally-defined Resource Attributes) and local Entity instance and Entity Type Attributes. Once an Attribute has been selected, clicking on the **Add** button will open up the **Assign Attribute Properties** dialog.



The combo box in the **Set Attributes** field contains the names of all the Attributes that the Assign Activity can access. Selecting an Attribute from the pull down list and then clicking on the **Add** button will open the **Attribute Assignment** dialog where the Attribute value is specified. Likewise, by selecting an Attribute from the left side of the **Set Attributes** list and clicking on the **Remove** or **Edit** buttons an Attribute assignment can be removed or changed.

The **Operation** field contains the operators that can be used to change the value of the selected Attribute. The supported operators are; =, +, -, *, and / (equals, addition, subtraction, multiplication, and division).

The **Value** field contains the value to be used with the **Operation**. This can take the form of a constant, a Statistical Distribution, a User-defined Function, or an Evaluate (Evl) Function. User-defined Functions can be found on page 293 of this chapter. The Evaluate Function is covered on page 263.

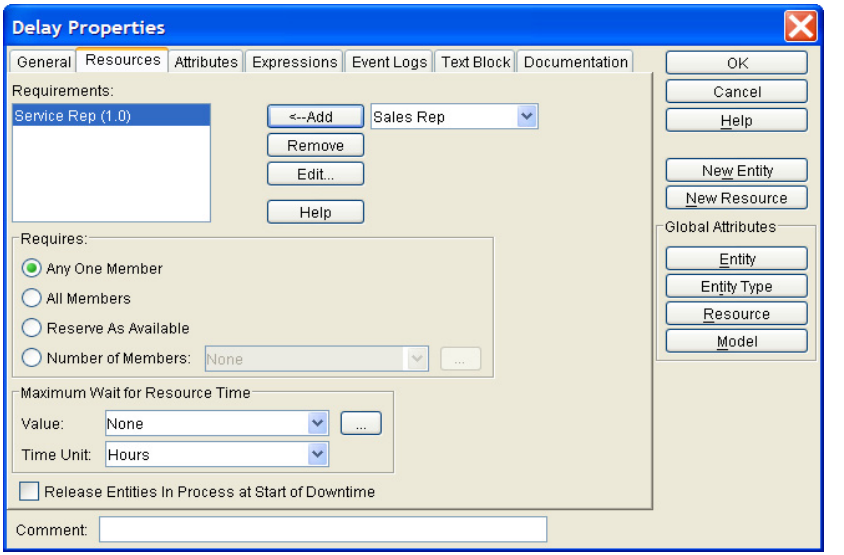


Each time an Entity enters the Assign Activity, the **Set Attribute** commands are performed.

Important: If the Attribute selected for assignment is a local Entity or Entity Type Attribute, a run time error will occur if an Entity enters the Activity that does not have the selected Attribute defined.

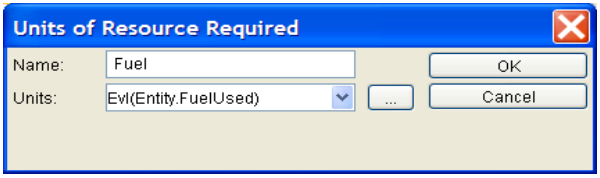
Variable Resource Usage

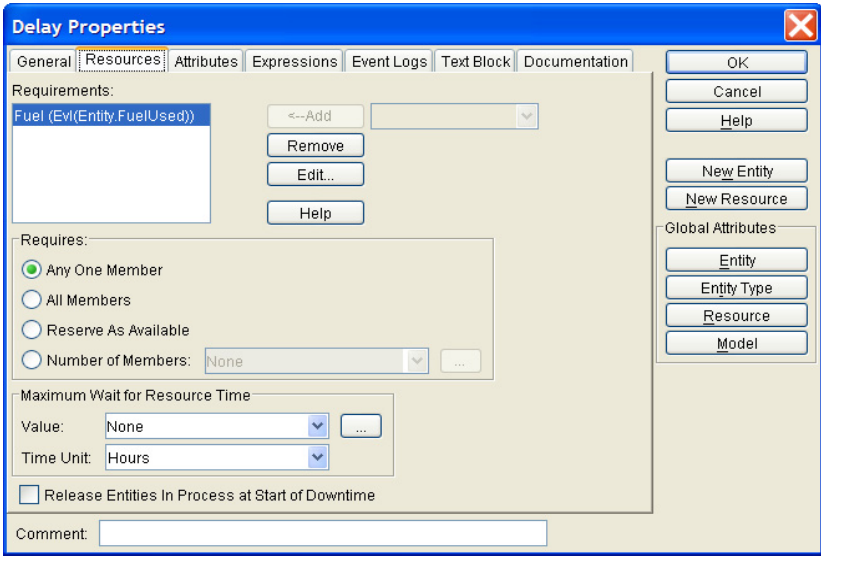
User-defined Attributes can be used to request units of Resources. Using an Attribute allows the units of Resource required by each Entity to vary. For instance, in the example from Chapter 5 (page 152) an Entity needed one unit of the Service Rep Resource for that Activity.



Thus, every Entity will get one and only one unit of the Resource. However, there may be instances where the amount of Resources needed would be different for each Entity. This is true many times when using consumable Resources (such as fuel). Any type of Attribute may be used to set these levels (Entity, Entity.Type, Resource, Activity, or Model). When Attributes are used, they must be provided in the Evl distribution function such as “Evl(Model.myattribute).” The Evl function gives added flexibility since mathematical functions can be used with the Attributes. “Evl(Model.myattribute + (Entity.myEntityattribute * SQRT(Activity.myActivityattribute))” is an example.

In addition to Attributes, any statistical distribution may be used. Use **Edit** to modify the existing requirement definition and then enter the Attribute that will have the unit information. The Attribute must be a real or integer type Attribute.





During the simulation run, if the units of Resource requested is larger than the Resource capacity, the Entity will not proceed since there will never be more units available than capacity. This will not occur when using consumable Resources. If the Resource is consumable, the Entity will continue when more Resource units are available. Also, if a fractional number of units is requested and fractional usage was not selected for the Resource, an error will occur.

Writing Expressions

The previous section discussed how to define user Attributes. This section discusses how to use them.

For Attributes to be useful, they must be able to be accessed and changed during a simulation run. SIMPROCESS provides opportunities to do this at many points during a simulation. The instructions written to process Attributes and SIMPROCESS model elements are called Expressions.

An Expression is a user-defined routine that runs within the larger SIMPROCESS program. In effect, SIMPROCESS checks at various points during a simulation run to see if there are any special instructions for it. If so, it runs the code. Expressions accomplish simulation and modeling requirements for which standard SIMPROCESS processing does not support.

The SIMPROCESS Expression language is introduced first, then how Expressions are implemented is explained.

SIMPROCESS Expression Language Basics

The SIMPROCESS Expression language contains the basic features of any programming language. Complex Expressions can be written in this language.

In the definitions that follow, the word *expression* with a lower case “e” refers to a mathematical expression. *Expression* with a capital “E” refers to the SIMPROCESS Expressions feature.

Types

SIMPROCESS supports a limited set of data types. The supported types are as follows:

- *BOOLEAN*

  A variable that contains the binary values of TRUE or FALSE

- *REAL*

  A variable that contains a real number

- *INTEGER*

  A variable that contains an integer number

- *STRING*

  A variable that contains an array of characters

Types are specified in either one of two ways: by declaring a variable local to the Expression such as the variables **`myReal`** and **`myString`**:

```
myReal : REAL;

myString : STRING;
```

or by selecting the Attribute type from the Attribute definition dialogs. The Attribute definition dialogs support the same types that can be declared locally in the Expression. However, the data type of Object is not supported in the Expressions. ANYOBJ is used instead of Object.

Operators

- *Assignment Operator*

  The assignment operator is used to assign a value to an Attribute:

  ```
  :=
  ```

  For example:

  ```
  x := 15;
  assignWeight := 1000;
  ```

  The colon (**:**) preceding the equal sign (**=**) is required. An error will occur if it is omitted.

  String values can be concatenated using the + operator:

  For example:

  ```
  mystring1:= "hello ";
  mystring2:= "dolly";
  mystring3:= mystring1 + mystring2;
  ```

  The string mystring3 now contains the value “hello dolly”. String concatenation can also be used on functions that return string values such as the SUBSTR function.

  For example:

  ```
  mystring1:= SUBSTR(0,5,mystring3) + " dude";
  ```

  The variable mystring1 will now contain “hello dude”.

- *Compare Operator*

  An equal sign without a preceding colon is used when comparing two values. Thus, the statement beginning:

  ```
  IF assignWeight = 1000...
  ```

compares the value of Attribute *assignWeight* to the number 1000.

- *Arithmetic Operators* used in the SIMPROCESS Expression language are **+** (addition), **-** (subtraction), ***** (multiplication), **/** (division), **DIV** (integer division), and **MOD** (modulus).
- *Relational Operators* include **=**, **<>** (not equal), **<, <=, >, >=.**

Literals

- A *string* of printable characters on a single line is enclosed in quotation marks:

```
"The plain in Spain looks lovely in the rain.";
```

- A *boolean* literal is entered as uppercase TRUE or FALSE:

```
myBool := TRUE;
```

- An *integer* literal is entered as a whole number:

```
myInteger := 67;
```

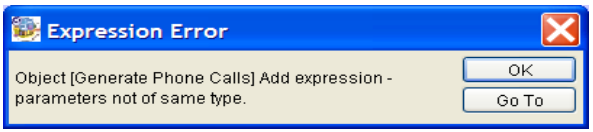
- A *real* literal is entered as a whole number plus a decimal, fraction, or whole number plus a fraction:

```
myReal1 := 67.;
myReal2 := 67.133;
myReal3 := 0.345;
```

Type Checking

- The use of variables (both those defined locally in the Expression and those defined as Attributes) in Expressions will be checked for correct type on assignment statements. For example, the following code will produce a type mismatch by the Expression interpreter.

```
myReal : REAL;
myString : STRING;
myString := "Hello Dolly";
myReal := myReal + myString;
```



System Methods

- System methods are commands which result in a system action or return a value from the underlying system. One commonly-used function is **SimTime**, which returns a Real number containing the current simulation time.
- For a list of System Methods available in SIMPROCESS, refer to page 521.

Expression Language Statements

- **IF condition**
  {ELSIF condition}
  {ELSE condition}
  END IF;
- **WHILE condition**
  END WHILE;
- **FOR expression TO|DOWNTO expression [BY expression]**
  END FOR;
- **RETURN (possible return value)**
- **EXIT (with WHILE or FOR loops)**
- **OUTPUT**

SIMPROCESS Expression language syntax:

1. The SIMPROCESS Expression language is case sensitive. An Attribute named **Applianceweight** is not the same Attribute as the Attribute referred to as **applianceWeight**.
2. All built-in language elements are in capital letters (**IF**, **END,WHILE**, etc.).
3. Each Expression language statement ends with a semicolon (**;**). The exceptions to this are lines that begin with **IF**, **ELSIF**, **ELSE**, **WHILE**, and **FOR**.
4. Comments can be included in Expressions by enclosing them in curly brackets (**{ }**). For example:

   {This is a comment}

   Do not end a comment line with a semicolon.
5. Basic conditional logic has the form:

```
IF a < b
 x := c;
ELSIF a < c
 x := d;
END IF;
```

For example:

```
IF batchweight > 2000
  MaxBatchSize := 100;
  batchWeight := 0;
ELSIF batchweight > 1800
  MaxBatchSize := 110;
END IF;
```

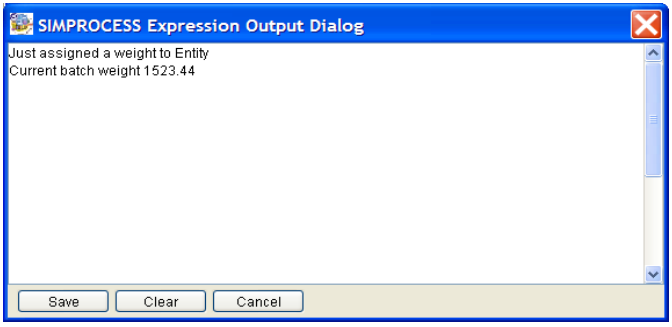
Messages can be displayed in the SIMPROCESS Expression Output Dialog with the **OUTPUT** statement. This is useful for tracking the value of Attributes as a simulation proceeds. The **OUTPUT** statement has the form:

```
OUTPUT(expression);
```

For example:

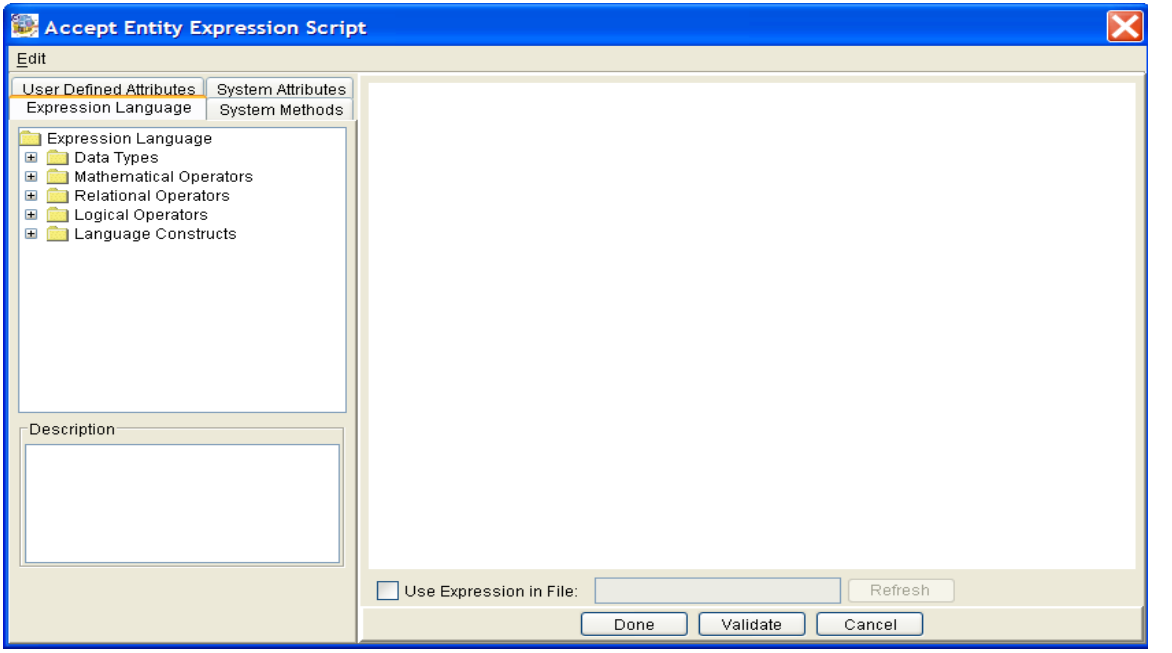
```
OUTPUT("Just assigned a weight to Entity");

OUTPUT("Current batch weight ",  batchWeight);
```

In the second example, the value of Attribute **batchWeight** is displayed following the text "`Current batch weight` ". The literal string and Attribute name are separated by a comma so the actual **batchWeight** value will appear next to the string.



Expression Editor

Editing any Expression activation event brings up the Expression Editor, shown below. On the right is the text area for entering the Expression. The dialog contains a single menu, **Edit**, which includes the traditional **Cut**, **Copy**, **Paste** and **Select All** items. It also includes **Find...**, **Replace...** and **Go To...** items, any of which display a dialog containing **Find**, **Replace** and **Go To Line** tabs. The **Find** and **Replace** features include matching case, whole word searching, search up/down direction selection, and a **Replace All** command. The **Go To Line** tab allows movement directly to any given line number of the expression text, which can be useful when a validation error message includes a line number. Entering a very large number goes to the last line; entering zero or a negative value goes to the first line; entering a non-numeric value causes an error message to be displayed.



On the left are four tabs (**Expression Language**, **System Methods**, **System Attributes**, and **User Defined Attributes**) listing the items that can be included in the Expression. The **Expression Language** tab lists data types, operators, and constructs of the SIMPROCESS Expression Language along with a description of the selected item. The **System Methods** tab lists the System Methods available for SIMPROCESS along with the **Arguments**, the type the system method **Returns**, and a **Description** of the selected item. The **System Attributes** tab lists the System Attributes defined for each simulation object in SIMPROCESS. Included is the **Get/Set** property of the Attribute, the **Type** of the Attribute (e.g., INTEGER, REAL), and a **Description** of the selected item. (See "SIMPROCESS System Attributes and Methods," beginning on page 511 for more information on System Attributes and

System Methods.) The **User Defined Attributes** tab lists all the global Attributes defined in the model and any local Attributes defined for the Expression owner including the **Type** of the selected Attribute. Double clicking an item on any of the lists causes the item to appear in the Expression text area.

The **Validate** button below the text area checks the syntax of the Expression without closing the editor. The **Done** button checks the syntax of the Expression and, if there are no errors, closes the Expression editor.

Expressions entered into the Expression editor are saved as a part of the model file. This is the preferred method of storing Expressions since copies made of the model file (either external to SIMPROCESS or with **Save As**) will automatically have any Expressions that were defined in the original model file, all the capabilities of the **Expression Search** feature (page 40) are available, and templates defined (page 225) will also have any Expressions included in the original item being templated. However, Expressions can also be stored in external files. This can be useful if the same Expression is used multiple places, or if there is a need to change an Expression without opening the model. The same Expression file can be used with multiple models, but this is discouraged since it is best if the Expression file is stored in the model's directory. Storing an Expression file in the model's directory shows clear linkage between an Expression file and a model. An Expression file must be an ASCII file. If a word processor is used to create the file, make sure the file is saved in text format. Note that when using **Expression Search**, if the **Search For** field is empty, the **Expression Search** will find any item that has an Expression whether stored in the model or stored in a file, but searches for specific text ignore Expressions in files.

To use an external file for an Expression select the **Use Expression in File** checkbox, and enter a file name in the adjoining text field. If the file name does not have a path included, the file is assumed to be in the model's directory. If a path is included, it must be a complete path. SIMPROCESS will not create the file entered in the text field. The file must be created by an editor independent of SIMPROCESS. When there is already a file assigned, the text of the Expression file is loaded into the Expression editor when the editor opens. If the file is assigned after the editor opens, the **Refresh** button can be used to load the Expression. Expressions from files are not editable in the Expression editor. The text of an Expression in a file is loaded into the Expression editor so the syntax of the Expression can be checked using the **Validate** button. Expressions edited in another editor should always have the syntax checked before running the simulation. If the syntax error is caught at run time the simulation will stop. If the **Validate** button shows there are errors, the Expression can be modified in another editor, the file re-saved, and then the Expression reloaded using the **Refresh** button. Clicking the **Done** button checks the syntax before closing the Expression editor. However, unlike when the expression is stored in the model, the option to close with errors is available.

If the **Use Expression in File** checkbox is deselected, the text of the Expression becomes editable. However, if the editor is closed with **Use Expression in File** deselected, the Expression becomes a part of the model. If **Use Expression in File** is reselected before closing the editor, any changes made are lost since Expressions are only read from the specified file. Changes to the Expression must be done and saved to the file in another editor. Expressions can be copied from the SIMPROCESS Expression

Editor and pasted into another editor by highlighting the desired text and using the **Copy** and **Paste** commands.

Using Attributes in Expressions

The value of an Attribute may be useful in the calculation of an Expression for a different construct than that for which the Attribute was defined. For instance, the duration of a Delay Activity could take the value of an Attribute of the Entity currently at the Delay Activity. To do so, the Expression on the Activity must access the value of the Attribute on the Entity. This is accomplished by referring to the Entity Attribute with the prefix "`Entity`." followed by the name of the Entity Attribute.

Using the duration example above, for an Entity Attribute called "**`TimeFactor`**", the duration that each Entity (that carries the **`TimeFactor`** Attribute) will spend at a Delay Activity can be set with the following statement:

```
NextDelay := Entity.TimeFactor;
```

By placing the above statement in the "`Accept Entity`" activation event (for a listing of activation events, see "Expression Activation Events," beginning on page 264) on the **Delay Activity**, the value of the System Attribute, **`NextDelay`**, will take the value of the **`TimeFactor`** Attribute. The result is, for each instance of an Entity reaching this Activity, its processing time at that Activity is determined by the value of the Entity Attribute, **`TimeFactor`**, that each instance of the Entity carries. However, this assumes that there is no wait for Resources. If an Entity has to wait, another Entity could enter and change **`NextDelay`** before the first Entity is able to process. The preferred method is to use the **Evaluate** function in the **Duration Value** field on the **Delay Activity** to return the value of the Attribute **`TimeFactor`**. This method is better, since the duration of each Entity at the **Delay Activity** is calculated from the **`TimeFactor`** Attribute. This is visible on the **Properties** dialog of the Delay rather than in an Expression. Also, there is no possibility of another Entity changing the value of the delay. See the "Evaluate (Evl) Function" on page 263 for more detail.

The format would be similar for an Entity Type Attribute. If the Attribute to be referenced was named "**`TypeTime`**", it would be used in the Expression of a construct other than an Entity as:

```
Entity.Type.TypeTime
```

The same holds true for Attributes of other SIMPROCESS constructs as well. An Activity Attribute called "**`ActivAttr`**" that is referenced in an Expression on a construct other than an Activity, would be referred to as:

```
Activity.ActivAttr
```

A Model Attribute called **`ModAttr`** would be referred to as:

```
Model.ModAttr
```

User-defined Resource Attributes can be accessed by an Expression from any other construct in SIMPROCESS, and values can be assigned to those Attributes by using the syntax described above. However, User-defined and System Attributes for Resources must be accessed by using the **Resource** System Method.

For instance, to reference the number of units currently busy of the Resource called **Resource1**, use:

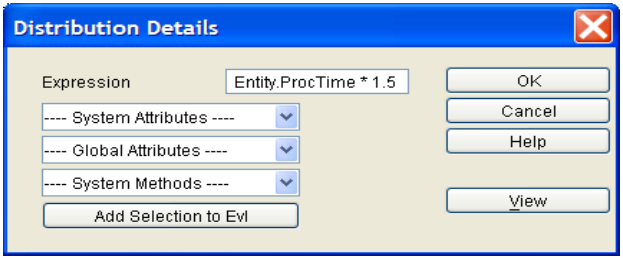
```
Resource("Resource1").UnitsBusy
```

These are just some basics of the SIMPROCESS Expression language. See "System Method Examples" on page 551 for more detail.

Evaluate (Evl) Function

The simplest use of an Expression is with the Evaluate (Evl) function. This function supports a single line Expression. That Expression can contain any of the System Methods, System Attributes, User-defined Attributes and Operators that are supported at the Activation Events level described in the next section. The Evl function can be found on any of the combo boxes where the standard distributions and User-defined Functions are listed.

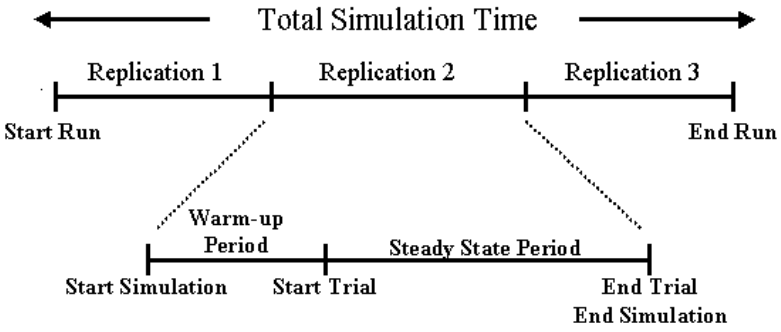
An example using the Evaluate function is a system with a processing time (Delay) that is a function of an Entity Attribute. Select the **`Evl(1.0)`** function on the **Hours** field from the Delay Activity's **Properties** dialog. Clicking the **Detail** button will open an **Evaluate** dialog where the Expression describing the processing time is entered. This example reads the Entity's processing time (given by the Entity Attribute **`ProcTime`**) and multiplies it by 1.5. This value would then be the delay time for the Activity. **`Entity.ProcTime`** could be typed in directly or selected from the **Global Attributes** list. Once selected in the **Global Attributes** list, the attribute can be added to the **Expression** by selecting **Add Selection to Evl**.



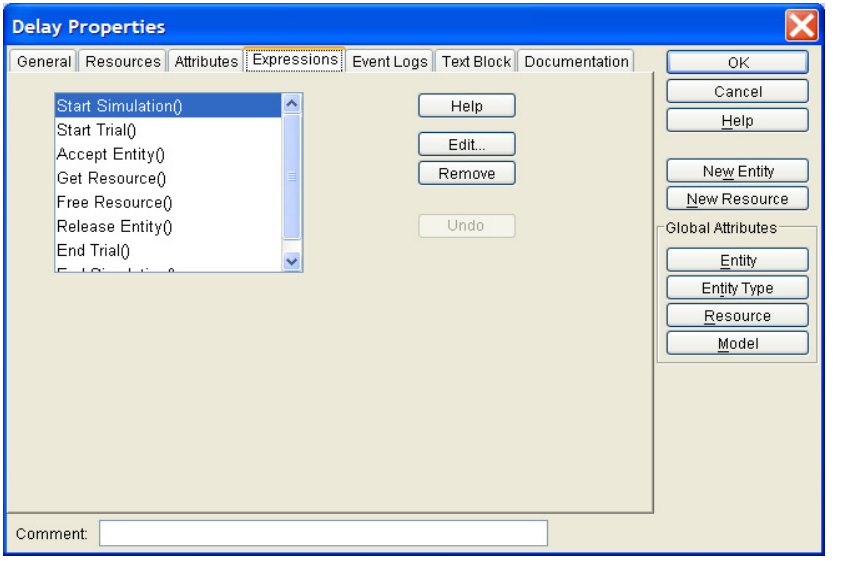
Expression Activation Events

SIMPROCESS has a set of activation points at which it checks for the existence of Expressions, and then runs those that it finds. An Expression is assigned to an activation point at the time it is defined.

Each activation point corresponds to a simulation event and has a name identifying it to SIMPROCESS. For example, the start of a replication is referred to as the **`Start Simulation`** event. The **`Start Trial`** event marks the beginning of a single trial within a replication (after warmup).

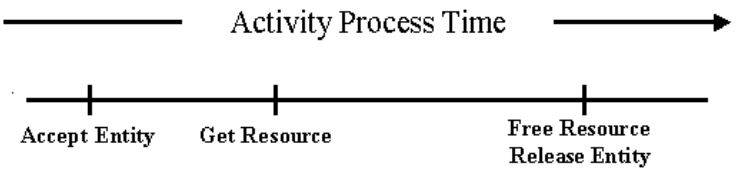


Some events can occur many times during a simulation. The **`Start Trial`** and **`End Trial`** events occur once during each replication of a multi-replication simulation. If the simulation contains only a single replication, these events occur just once. The **`Start Simulation`** and **`End Simulation`** events occur once during each replication of a multi-replication simulation if **Reset System** is selected in the **Simulation Run Setting** dialog. Otherwise, the **`Start Simulation`** event occurs just once at the beginning of the first replication. The **`End Simulation`** event occurs at the end of the last replication. These are specified on the **Expressions** tab of Process, Activity, Resource, and Entity Type dialogs.



`Start Run` and **`End Run`** are model Expressions only (menu **Define/Model Expressions**). These Expressions are executed only once no matter how many replications are run. **`Start Run`** is the very first Expression executed, and **`End Run`** is the very last Expression executed. These Expressions are particularly useful for opening and closing files that are needed throughout the simulation. (See "Methods OpenFile, CloseFile, ReadFromFile:," beginning on page 555 for information on opening and closing files.) The **`Start Simulation`** and **`Start Trial`** model Expressions are executed before the **`Start Simulation`** and **`Start Trial`** Expressions of Entity Types, Resources, Activities, and Processes. The **`End Simulation`** and **`End Trial`** model Expressions are executed after the **`End Simulation`** and **`End Trial`** Expressions of Entity Types, Resources, Activities, and Processes.

Events related to Entities and Resources can occur numerous times throughout a simulation trial. For example, an Entity's arrival at an Activity is a simulation event called **`Accept Entity`** (so-called because the Entity is being accepted into the Activity). This can occur thousands of times during a long simulation, once for each Entity that arrives at the Activity.



Every Expression is associated with a specific SIMPROCESS model element. Select the model element that requires customized processing, specify the event at which the processing is to occur, and then write the Expression to do the processing. "Example: Batching Entities Based on Weight" on page 270, describes this Process in detail.

Not every event is available as an activation point for every model element. For example, the initial value of an Attribute for an Entity can be set when the Entity is first generated (**`Initialize Entity`**), or when the Entity is released from a Generate Activity (**`Release Entity`**). But the value of an Entity Attribute cannot be set when the simulation first begins to run (**`Start Simulation`**), because no Entities have been generated at that point.

The table below contains a complete list of activation events. Note that the order of the elements is the order in which the Expressions are executed.

Event Name	Activation Point (and Comments)	Model Elements Active For:
Start Run	The beginning of a simulation run. Occurs only once, no matter how many replications.	Model.
Start Simulation	The beginning of the first replication, before the warm-up period (if any). If **`Reset System`** is selected, it occurs at the beginning of each replication.	Model. Entity Types. Resources. All Activities.
Start Trial	Beginning of a trial within the simulation, after the warm-up period (if any).	Model. Resources. Entity Types. All Activities.
Initialize Entity	Creation (allocation) of an Entity. This typically occurs in a Generate Activity, but may also occur in the Batch, Transform, Copy, Split, and Assemble Activities.	Entity Instances. Entity Types.
Accept Entity	Arrival of an Entity at an Activity or Process.	Processes plus all Activities except Generate. Entity Instances.
Get Resource	Obtainment of a Resource by an Activity.	Resources. All Activities except Generate, Free Resource, & Dispose.
Interrupt Processing	Entity processing is interrupted by a higher priority Entity or by a Resource going down.	Entity Instances.
Resume Processing	Entity processing is resumed after interruption.	Entity Instances.
Free Resource	Release of a Resource by an Activity.	Resources. All Activities except Generate, Get Resource, & Dispose.

Event Name	Activation Point (and Comments)	Model Elements Active For:
Release Entity	Release of an Entity from an Activity or Process.	Processes plus all Activities except Dispose. Entity Instances.
Dispose of Entity	Dispose of an Entity.	Entity Instances. Entity Types.
Start Downtime	Resource initiates a downtime.	Resources.
End Downtime	Resources ends a downtime.	Resources.
End Trial	End of a simulation trial.	Model. Entity Types. Resources. All Activities.
End Simulation	The end of a simulation replication. Statistic collection for the replication ends at this point.	Model. Entity Types. Resources. All Activities.
End Run	The end of a simulation run. Occurs only once at the end of all replications.	Model.

Attribute Value Initialization

User-defined Attributes can be initialized at several places in a SIMPROCESS model. The following procedure shows how SIMPROCESS sets Attribute values along the simulation timeline.

When the simulation is started, SIMPROCESS will:

1. Initialize Attributes to the values that are specified in the **Attribute Definition** dialog
2. Execute the reset system mechanism if the **Reset System** option is selected and **Do Not Reset Before Each Replication** is not selected (reset Attribute to the values specified in the **Attribute Definition** dialog)
3. Execute any Start Simulation Expressions (Attributes can be set to different values in these Expressions).

After a replication is complete, SIMPROCESS may reset Attribute values for the next replication. If the **Reset System** option is selected in **Run Settings**, SIMPROCESS will continue on the next replication starting from item 2, as listed above. Otherwise, it will start from item 3.

Example: Batching Entities Based on Weight

This example describes a method of releasing Entities based on weight, an Attribute that SIMPROCESS is not inherently aware of. The model depicts the product distribution Process of an appliance manufacturer. Here is a simplified view of the model:

1. Appliance orders are received from customers.

   This is the Generate Activity. Each appliance order is an Entity.
2. The orders are processed and eventually make their way to a distribution center in the form of appliances.

   This takes place within a subprocess. The details are not important for this example.
3. Appliances are shipped to customers from the distribution center. A Batch Activity is used to ship appliances as a group.

   Shipments are released when the total weight of all appliances awaiting delivery reaches 5000 pounds.

In order to accomplish the objective of releasing the batch when a certain weight is accumulated, do the following:

1. Define Attributes to represent the weight Attribute of Entities (define global Entity Attribute **`applianceWeight`**).
2. Assign values to the weight Attributes.
3. Accumulate and track the weight of Entities received at the Batch Activity (define local Attribute at Batch Activity named **`batchWeight`**).
4. Trigger the release of Entities if a specified weight is reached, and prevent the release of Entities otherwise.

Build Process Flow

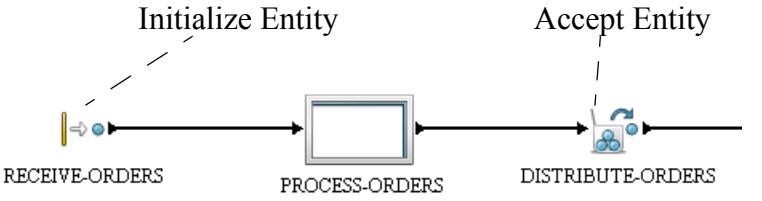
Open a new model and place a Generate Activity, Process, Batch Activity, and Dispose activity on the layout. Connect the Activities. Descend into the Process and connect the incoming Input Pad to the outgoing Output Pad. The details of the Process are not important for this example.

Initializing Entity Attributes

First, assign a value to the *applianceWeight* of each Entity generated during a simulation. This can be done as soon as the Entity is created. Then, when the Entity reaches the Batch Activity, add its weight to a running total and compare this total to the maximum allowable weight. The points in the simulation where Expressions need to be activated are:

- Entity initialization
- Receipt of the Entity by an Activity.

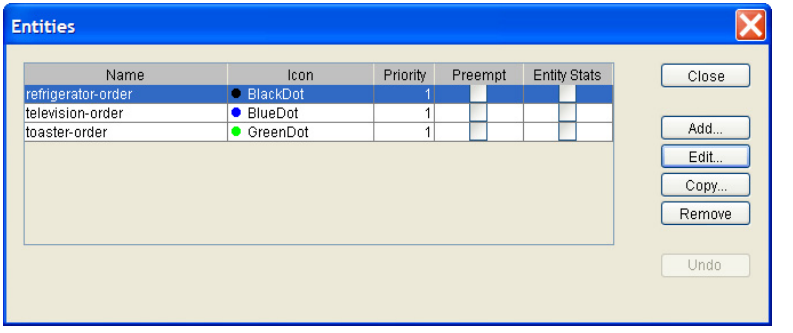
Entities are initialized by SIMPROCESS at the **`Initialize Entity`** event. Entities are received by an Activity at the **`Accept Entity`** event.



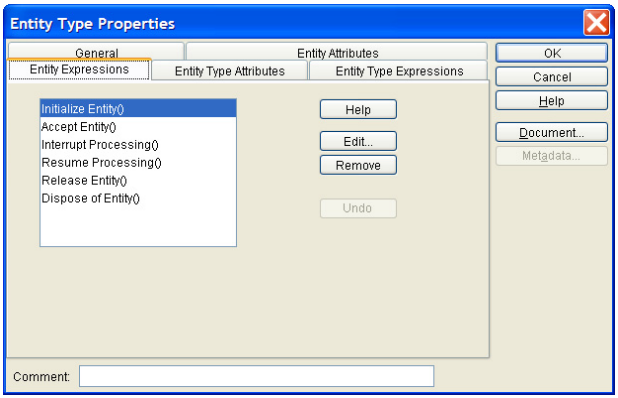
Defining the Expression at Entity Initialization

To assign an initial value to an Entity's **`applianceWeight`**, define an Expression for each type of Entity in the model. The Expression is a single assignment statement (e.g., **`applianceWeight := 1000.0`**) to be executed when the Entity is first generated (the **`Initialize Entity`** event):

1. From the **Define** pull-down menu, select **Entities**.



2. This model contains three Entity types. An Expression must be defined for each Entity. Start by selecting the first Entity on the list, and then press **Edit**.
3. Every refrigerator-order Entity that is generated needs to be initialized, so select the **Entity Expressions** tab.



4. Six simulation events are listed on the **Entity Expressions** tab. These are the points during the simulation at which SIMPROCESS checks for Expressions which apply to Entity instances.

   The event needed is **`Initialize Entity`**, which is the point at which an Entity is first generated (initialized). Highlight **`Initialize Entity`** and click on **Edit**.
5. SIMPROCESS invokes the Expression editor and opens an Expression script dialog. Add just one line to the text dialog:

   ```
   applianceWeight := 1000.0;
   ```

   This assigns a value of 1000.0 to **`applianceWeight`**.
6. Close the editor.
7. Follow the same procedure for each of the Entities in the model, but assign them different weights. Assign a weight of 100.0 to *television-order* and 10.0 to *toaster-order*.
8. Click **OK** when finished.

Defining the Expression When an Entity Is Released

The method described above works fine to initialize the **`applianceWeight`** Attribute of Entities. It's fairly simple, too; it requires only a single statement in each Expression. But it is redundant in that Expressions must be defined for each type of Entity. Defining an Expression for each Entity would be tedious and time consuming if there are many different types of Entities.

There are other options. A weight does not have to be assigned to the Entities as soon as they are created.

All that is required is the weight be assigned before the Entity reaches the Batch Activity where appliances are distributed (DISTRIBUTE-ORDERS).

In this model, all Entities are generated by a single Generate Activity. So an Expression can be defined in the Generate Activity that activates whenever an Entity is released (**`Release Entity`** event). This is the most efficient way to proceed. One Expression handles the initialization of any Entity's **`applianceWeight`**.

1. Double-click on the Generate (RECEIVE-ORDERS) Activity.
2. In the **Generate Activity Properties** dialog, click on the **Expressions** tab. Five simulation events are listed. The first, **Start Simulation,** will occur before any Entities are generated. **Start Trial** will occur before any Entities are generated if there is no warmup period; otherwise, some Entities could be generated if Entity generation was scheduled during the warmup period. **Release Entity** serves the purpose, so highlight it and click on **Edit**.
3. Enter the following lines in the Expression dialog:

```
IF Entity.Name = "refrigerator-order"
   Entity.applianceWeight := 5000.0;
ELSIF Entity.Name = "television-order"
   Entity.applianceWeight := 100.0;
ELSE
   Entity.applianceWeight := 10.0;
END IF;
```

   These instructions check the name of the Entity being released at the Activity. The name identifies the type of Entity. A value is assigned to **`applianceWeight`** based on the Entity type.
4. Close the editor.
5. Click on **Close**, and then **OK**.

Releasing Entities Based on Weight

Two more Expressions are needed to complete the model. In the first Expression, check the weight of the Entities received at the batch Activity and trigger their release if the weight reaches a certain number:

1. Double-click on the DISTRIBUTE-ORDERS Activity.
2. In the **Batch Activity Properties** dialog, click on the **Expressions** tab.

3. There are eight activation events listed on the **Expressions** tab for a Batch Activity. **Accept Entity** occurs when an Entity arrives at the Activity, so highlight this event and click on **Edit**.
4. Insert the following code:

```
batchWeight := batchWeight + Entity.applianceWeight;
IF batchWeight >= 5000.0
   MaxBatchSize := NumberIn;
   OUTPUT("Batch weight is ",
      batchWeight);
      batchWeight := 0.0;
END IF;
```

   In this Expression, the weight of the just-received Entity is added to the total weight of all Entities received. If the total weight exceeds 5000.0, a batch release is triggered by resetting **MaxBatchSize**, the Attribute that sets the maximum number of Entities that can be held in the batch. With the Activity about to be emptied of Entities, the **batchWeight** Attribute is reset to zero.

   The **OUTPUT** statement in the Expression is there as an example of displaying information in the message dialog. It is not needed by the model. **OUTPUT** statements can be interspersed in Expressions in order to trace events during a simulation. Displaying the value of **batchWeight**, for instance, verifies that the batch is really released when the weight exceeds 5000.0.
5. Close the **Accept Entity** editor.
6. Edit the **Start Simulation** event. Enter the code below. This causes the Batch Activity to wait for the logic in Accept Entity to cause a batch release.

```
MaxBatchSize := 10000;
```

7. Close the **Start Simulation** editor.

There is one more thing this model needs. The maximum batch size must be reset again after the Entities are released. Entities should not be released when the DISTRIBUTE-ORDER batch reaches a certain number. Only accumulating 5000 pounds of weight should trigger release.

As it stands now, **MaxBatchSize** is set to the size of the previous batch accumulated at the Activity. This was done to force a release of Entities when **batchWeight** reached 5000 pounds. The number of Entities could reach the current **MaxBatchSize** again before accumulating 5000 pounds of weight. To prevent that, reset this Attribute to a number that can not possibly be reached before accumulating 5000 pounds of weight:

1. In the **Expressions** tab, select **Release Entity.** This is the event where the Entities are released from the batch Activity.

Press **Edit**.

2. Enter the following statement:

```
MaxBatchSize := 100000;
```

3. Close the editor.

The model should now be ready to run.

An Alternative Method Using Entity Types

This example works fine, but there are alternative approaches (as there often are when building models in SIMPROCESS).

A couple of alternatives have already been described for initializing the value of the **applianceWeight** Attribute ("Defining the Expression at Entity Initialization" on page 271 versus "Defining the Expression When an Entity Is Released" on page 272). Another alternative involves defining the **applianceWeight** Attribute for Entity types instead of Entity instances.

In this example, a weight Attribute was defined for every Entity instance in the model. Every refrigerator order was assigned a weight of 5000, every television order, 100, etc. The assigned weights remained unchanged during the course of the simulation.

Another approach would be to define an **applianceWeight** Attribute for each Entity type and initialize it at the **Start Simulation** event. Then, in the Expression defined at **Accept Entity** for the DISTRIBUTE-ORDERS Activity, the Entity's weight would be referenced as:

```
Entity.Type.applianceWeight
```

This would work fine for this example. But suppose that the weight of an order could be affected by some step in the Process being modeled and this needed to be reflected in the model. For example, a customer order could include accessories for an appliance (e.g., cables and remote control for a television), adding to the weight of the order. In that case, attaching the **applianceWeight** Attribute to each Entity instance allows the weight of each television order to vary, which cannot be done if the Attribute belongs to the Entity's type.

Using Object Attributes in Expressions

The code in this example uses an Expression language construct referred to as a *qualified reference*. For instance:

```
Entity.Name
```

refers to an object, named **Entity**, and an Attribute, **Name**.

An *object* Attribute leads SIMPROCESS to the model element containing the Attributes of interest. Unlike other Attributes, the value of the object is not of interest, only the values of its system or user Attributes.

In step 3, the type of Entity being released by the Generate Activity was identified. The System Attribute **Name** identifies the Entity type. But a **Name** Attribute also identifies Resources and Activities. So referring to **Name** alone is ambiguous. In fact, SIMPROCESS assumes the reference is to the model element that called the Expression (the **RECEIVE-ORDERS** Activity). To avoid confusion in the Expression, always qualify Attributes with the object name such as (Entity.Name, Self.Name, Activity.Name, Self.myattribute, etc.).

That is where object Attributes come in. They identify the model element of interest.

- The **Entity** object Attribute tells SIMPROCESS to look at the Entity being processed in the current Activity.
- An Attribute called **Self** points at the current model element; that is, the model element the Expression has been invoked from.

So **Entity.Name** returns the type name of the Entity instance being processed at the **RECEIVE-ORDERS** Activity, while **Self.Name** returns the name "**RECEIVE-ORDERS**."

A qualified reference is also employed to set the User Defined Attribute **applianceWeight:**

```
Entity.applianceWeight := 5000.0;
```

Now, **applianceWeight** was specifically defined as an Attribute of Entities. However, this does not mean that any reference to this Attribute would be unmistakable, that it can only refer to one thing.

But in fact, the reference to **applianceWeight** must be qualified by an object reference. This is because without specifying a qualifier, SIMPROCESS assumes the reference is to an Attribute of the current model element. In this case, the current model element is the Generate Activity, **RECEIVE-ORDERS**, since it is the model element which invoked the Expression. There is no Attribute named **applianceWeight** associated with this Activity, and an unqualified reference to **applianceWeight** would result in an error.

Note that an unqualified reference to the Attribute **Name** refers to the name of the current model element, **RECEIVE-ORDERS**. If that is the Attribute of interest, the Attribute does not have to be qualified.

Object references can be stacked to gain access to variables that may not be within the scope of the current object but may still be of interest in an Expression. For example, the following Expression snippets are valid uses of object references from within an Activity Expression under the Accept Entity event.

```
OUTPUT("In ",Self.Name, " Entity = ", Entity.Name);

{ produces the name of the Activity and the name of the current
   Entity  }

OUTPUT("In ",Self.Name, " Entity Type = ", Entity.Type.Name);

{ produces the name of the Activity and the name of the current
   Entity's type  }

OUTPUT("In ",Self.Activity.Name, " Entity = ",
   Activity.Activity.Entity.Name);

{ produces the name of the Activity and the name of the current
   Entity  }
```

Notice in the third OUTPUT example, the object reference to the current Activity is stacked. In other words, the Object Self points to itself, and the Activity object also points to the current Activity. This is basically a circular reference and does not really do anything other than slow down the simulation and confuse anyone that may read the Expression (something like Activity.Activity.Activity.Entity.Name could also have been used which is the same result but is even more confusing). The Expression language allows this feature so that access can be gained to certain objects when appropriate. Consider the following example from within a Resource Expression under the Get Resource event:

```
OUTPUT("In ",Self.Name, " Activity.Entity.Name  = ",
   Activity.Entity.Name);

{ produces the name of the Activity and the name of the current
   Entity in that Activity  }
```

The above statement gains access to the Entity in the Activity that is assigning the Resource. When using the stacked object references, pay close attention to what is the current state of the model. Consider the following example for an Entity Expression under **Initialize Entity** event.

```
OUTPUT("In ",Self.Name, " Activity = ", Activity.Name);

{ produces an error  }
```

The above OUTPUT statement produces an error since there is no Activity object in scope at the time an Entity is initialized. An Entity must be accepted into an Activity before the above statement would work. This is a good example of being aware of the state of the simulation when referencing objects. Other common mistakes are using the Resource object references (for example, Resource("myResource").Activity.Name from within an Activity Expression before the Get Resource event has occurred) or Sibling and Child references without considering the state of the Siblings and

Children (for example, Sibling("Delay6").Entity.Name may produce an error if there is no Entity current in the Delay6 Activity).

Object references are very powerful but can be confusing. It is recommended that the simplest form possible of object reference be used in Expressions and that objects be accessed from the most obvious point of scope (i.e., placing the Expressions behind the appropriate events).

The use of object reference also applies to the Child, Parent, and Sibling references. Any number of object references can be stacked and return appropriate results unless a Child or Sibling is referenced that does not exist, or a Parent is referenced from the top-level diagram - all of which will return an error and terminate the simulation. The following example would work in a Process Expression as long as it was invoked from a Process that is at least three levels deep, has a Sibling named "Delay6", and a Child named "Delay7":

```
OUTPUT("In ",SelfName, " Sibling = ", Sibling("Delay6").Name,
   Child("Delay7").Name), " two parents up = ",
   Self.Parent.Parent.Name;

{ produces the name of the Activity, the name of Delay6, the name
   of Delay7, and the name of the parent's parent of the current
   Process  }
```

There are certain cases where it may be necessary to use object references as variables to gain further control over what Attributes can be accessed or to provide some flexibility in an Expression. There are basically two ways to use object references in variables: define local script variables of type ANYOBJ, or define SIMPROCESS user-defined variables of type Object. Note that both of these applications allow the variable to be setup as an array (just like any other variable type). Consider the following examples:

```
{ this expression is placed in the Accept Entity event of an Activity
   that has two local attributes defined - Attribute1 is a String
   and Attribute2 is of type Object }

myobj : ANYOBJ;

myobjarray[5] : ANYOBJ;

myobj:=Self;

{ points to the Activity the script is in  }

myobjarray[0]:=Activity.Entity;

{ points to the current Entity in the Activity }

myobjarray[1]:= Sibling("Delay6");
```

```
{ points to a sibling Activity called Delay6 }

myobjarray[2]:= Resource("myResource");

{ points to a Resource defined in the model }

Self.Attribute1:="hello dolly";

Self.Attribute2:=myobjarray[0];

{ points to the Activity.Entity object assigned to cell 0 of
   myobjarray above }

Self.Attribute2:=myobjarray[1];

{ now points to the sibling Delay6 assiged above}

myobj.Attribute1:="hey mister";

{ replaces the value in attribute1 with the new string "hey mister"
   since myobj also points to self - see above }

myobjarray[4]:=myobj.Entity.Type;

{points to the Entity type of the current Entity in the current
   Activity }

myobjarry[5]:= myobj;

{ produces an error since myobjarray has only cells 0 - 4 defined
   -  the subscript is out of bounds ]
```

Type checking is done on the assignment of variables where possible. This is to prohibit assigning basic type (REAL, INTEGER, STRING, etc.) variables to Object-type variables. Likewise, it precludes assigning object references to basic types. The following lines in the same script above would produce errors, and the simulation would terminate.

```
myobj := "hello dolly";

{produces an error because myobj is of type ANYOBJ and "hello dolly"
   is of type String  }

Self.Attribute1:=Entity;

{produces an error because Attribute1 is of type String and Entity
   is of type object  }
```

Note (as seen in the examples above) that type checking is not done between object type variables. For example, if an Entity object is assigned to a variable defined as an object, an Activity or Resource object can be assigned to that same variable without causing any errors. However, the Expression may not work properly if the variable should contain an Entity object reference and another object type has been assigned to it.

There are a few special rules on object references. Self and Model object references can only be used as the first reference in an Expression statement. Something like

```
myobj:=Self.Activity.Self;
```

results in an error, since Self can only appear as the first object reference qualifier for the statement.

Getting and Freeing Resources Using Expressions

There are two system methods for getting and freeing Resources: **GetResource** and **FreeResource**. "SIMPROCESS System Methods" on page 521 summarizes the methods. These system methods provide the same basic capability as the Get Resource and Free Resource Activities. (See "Get Resource and Free Resource Activities" on page 155.) The main difference is that with the Get Resource system method, the Resource requested can be different for every Entity. The Get Resource Activity assumes each Entity entering the Activity requires the same Resources. Thus, if different Resources are needed, the Entity must be routed to a different Get Resource Activity that requests those Resources. The demonstration model, **H2O.spm**, which is included in the SIMPROCESS installation, compares the usual method of obtaining resources with the **GetResource** system method. The model is described in Chapter 5 of the *SIMPROCESS Getting Started Manual*.

GetResource

GetResource can be used in several Activities that can acquire Resources (Get Resource, Delay, Branch, Transform, Gate, Synchronize, and Assign Activities). The Expression to get a Resource **must** go in the **Accept Entity** Expression of the Activity. **GetResource** may not be used in an Entity, Entity Type, or Resource Expression. The full command is

```
GetResource("Resource", "Units", "Tag");
```

The first parameter must be a String and is the Resource name. The second parameter can be a String, Integer, or Real. This is the number of units of the Resource to acquire. By allowing the second parameter to be a String, distributions can be used. The third parameter must be a String, but it is optional. This parameter corresponds to the tag used in the Get Resource Activity. The tag defaults to **any tag!** if the third parameter is omitted. If multiple **GetResource** system methods are used at an Activity, the Resources are obtained based on the rule set in the Resource usage of that Activity. The rules are **Any One Member**, **All Members**, **Reserve As Available**, and **Number of Members**. The default is **Any One Member**. Therefore, if multiple **GetResource** system methods are used, only one of the Resources will be acquired if the Resource acquisition rule has not been set to **All Members**. No Resources have to be listed in the Resource usage dialog for the Resource acquisition rule to be set.

When requesting Resources on the **Resources** tab of Activity properties, a particular Resource can only be added to the **Requirements** once. Thus, the selected acquisition rule always applies to different Resources. However, since a **GetResource** system method is equivalent to a Resource listed under **Requirements**, if two **GetResource** system methods in the same activity reference the same Resource then each **GetResource** request is treated in the same manner as if each referenced different Resources. For example, assume the following statements are in the Accept Entity expression of an Activity.

```
GetResource("Resource1", 1);
GetResource("Resource1", 1);
```

If the acquisition rule is **Any One Member**, then only one unit of Resource1 will be acquired since each statement is considered a "Member". If **All Members** is selected, then two units of Resource1 will be acquired. Note that if Resource1 only has one unit defined, then the above statements will generate a runtime error if **All Members** or **Reserve As Available** (which requires all members) are selected.

FreeResource

FreeResource can be used in several Activities that can release Resources (Free Resource, Delay, Branch, Transform, Gate, Synchronize, and Assign Activities). Just like **GetResource**, **FreeResource must** be used in the **Accept Entity** Expression of the Activity, and **FreeResource** may not be used in an Entity, Entity Type, or Resource Expression. Both of these methods must go in the **Accept Entity** Expression because these methods set up the requests for the events to occur while the Entity is processing in the Activity. Therefore, order within the **Accept Entity** Expression does not matter. A **FreeResource** system method for a particular Resource can come before the **GetResource,** since this is occurring when the Entity is being accepted into the Activity. However, since these system methods operate like the Activities of the same name, the **FreeResource** for a particular Resource can be in a different Activity from the **GetResource** for that Resource. If the **FreeResource** is in a different Activity, the Resource will not be released until the Entity has completed processing in that Activity, even though the **FreeResource** system method is in the **Accept Entity** Expression. The full command is

```
FreeResource("Resource", "Tag", TRUE);
```

The first parameter must be a String. It is the name of the Resource to be released. The second parameter must be a String as well. This is the tag of the Resource to be released. The third parameter is a Boolean (thus only TRUE and FALSE are allowed). For consumable Resources, this determines whether the Resource should be consumed. The third parameter is optional. If omitted, it defaults to TRUE (meaning the Resource should be consumed). This parameter has no effect on non-consumable Resources. The second parameter (tag) is also optional. However, if the second parameter is omitted, the third parameter must also be omitted. The tag defaults to **any tag!** if the tag parameter is missing. There are two keywords for this system method: **AnyResource** and **AnyTag**. These can be used in the place of the Resource parameter and the tag parameter. So possible options are (without the last parameter):

- `FreeResource("Resource1", "myTag");`
- `FreeResource("Resource1", "AnyTag");`
- `FreeResource("Resource1");` this operates the same as the previous
- `FreeResource("AnyResource", "myTag");`
- `FreeResource("AnyResource", "AnyTag");`

- **`FreeResource("AnyResource");`** this operates the same as the previous

These are the same combinations that are available in the Free Resource Activity. The following example shows getting and freeing a Resource at a typical Delay Activity.

```
GetResource("Sales Rep", 1);
FreeResource("Sales Rep");
```

Combining Get and Free Expressions With Activities

These system methods can be used with the Get Resource and Free Resource Activities. Any Resource obtained with the **`GetResource`** system method can be released by a Free Resource Activity. However, it is important to note that tags used in a **`GetResource`** system method will not be available in a Free Resource Activity if those tags have not been used in a Get Resource Activity. Likewise, any Resource obtained with a Get Resource Activity can be released with a **`FreeResource`** system method.

Creating Resources Using Expressions

For most models, Resources are defined when the model is created using the **Define/Resources** menu item. (See "Resource Modeling Constructs" on page 147.) This is done because the Resources that are required by the model are known when the model is created. However, there are times when the design of the model requires that the model be configured from an outside source (such as a database). In this instance, the number of resources and their characteristics may not be known until runtime. In this scenario, the model is typically run without the SIMPROCESS Graphical User Interface (GUI) using the SIMPROCESS Dispatcher or other methods for running a model apart from the SIMPROCESS GUI. (See "Running Models Without GUI" on page 599.) There are four system methods for creating and configuring Resources: **`CreateResource`**, **`SetResourceCost`**, **`SetResourceDowntime`**, and **`SetResourceExpression`**. "SIMPROCESS System Methods" on page 521 summarizes the methods. **`SetResourceCost`**, **`SetResourceDowntime`**, and **`SetResourceExpression`** can be used with Resources created using **`CreateResource`** or with Resources defined when creating the model (**Define/Resources**).

These system methods are not intended for the novice user. The proper use of these system methods requires indepth knowledge of simulation modeling and SIMPROCESS.

CreateResource

This statement creates a new Resource within a SIMPROCESS model. **`CreateResource`** can only be used in the **Start Run** Expression (**Define/Model Expressions**). Resources cannot be created during a trial or between replications. The full command is

```
CreateResource(Name:STRING, Units:REAL, Fractional:BOOLEAN,
Consumable:BOOLEAN, ResourceStats:BOOLEAN,
ResourceByActivityStats:BOOLEAN);
```

The first parameter is a String and must be a unique Resource name. The second parameter sets the starting capacity of the Resource. The parameters **`Fractional`**, **`Consumable`**, **`ResourceStats`**, and **`ResourceByActivityStats`** must be **`TRUE`** or **`FALSE`**. Fractional Resource usage is allowed if the **`Fractional`** parameter is **`TRUE`**. The Resource will be consumed when released if the **`Consumable`** parameter is **`TRUE`**. (Note that consumable Resources created with **`CreateResource`** can only be replenished by using the **`IncreaseCapacity`** system method.) Resources created at runtime will have statistics collected if **Collect Resource Statisitics** or **Collect Resource by Activity Statistics** are selected on the **Statistics Collection** dialog (**Report/Define Global Statistics Collection**, see "Default Performance Measures," beginning on page 186). Statistics will also be collected if **`ResourceStats`** and/or **`ResourceByActivityStats`** are set to **`TRUE`**.

For example, consider a scenario where the Resources for a model are stored in a database. The following code (in the **Start Run** Expression) reads the database and creates the Resources. (**`RunId`**

and **Database** are Model Attributes which were previously initialized.)

```
sql : STRING;
name : STRING;
units : REAL;
sql := "Select Name, Units from Resource_Table where RunId=" +
   INTTOSTR(Model.RunId);
ReadFromDatabase(Model.Database, "Set", sql);
WHILE GetNext("Set")
  name := GetResult("Set", "Name");
  units := GetResult("Set", "Units");
  CreateResource(name, units, FALSE, FALSE, FALSE, FALSE);
END WHILE;
```

Once a Resource has been created, other characteristics can be set (Cost, Downtime, and Experssions). Note that local Resource Attributes cannot be created through Expressions. However, global Resource Attributes can be used by Resources created using **CreateResource**. Most likely, other global Resource Attributes would be created to hold information about the Resource, such as **ID** or **Description**. The value of these Attributes would be obtained from the external source.

SetResourceCost

SetResourceCost is used to set the value of a Resource cost. (See "Activity-Based Costing" on page 176.) A nonconsumble Resource can have four types of cost, three of which are variable and one that is fixed. A consumable Resource can have two types of cost, both of which are variable. This system method is not limited to the **Start Run** Expression. It can be used at any point during a simulation run. However, changes to cost values made during a run will not take effect until a new cost period begins. The full command is

```
SetResourceCost(ResourceName:STRING, Cost:REAL, CostType:STRING,
TimeUnit:STRING);
```

ResourceName is the name of the Resource to which the **Cost** applies. The **Cost** must be greater than or equal to zero. For a nonconsumable Resource, **CostType** can be **PerEntity**, **PerUnit**, **PerTimeUnit**, or **Fixed**. **CostType** can only be **PerEntity** or **PerUnit** for a consumable Resource. When the **CostType** is **PerTimeUnit**, the **TimeUnit** must be one of the valid SIMPROCESS time units (**Nanoseconds**, **Microseconds**, **Milliseconds**, **Seconds**, **Minutes**, **Hours**, **Days**, **Weeks**, **Months**, **Years**). When the **CostType** is **Fixed**, the **TimeUnit** must be **Weekly**, **Monthly**, **Quarterly**, **Half-Yearly**, or **Yearly**. If the **CostType** is **PerEntity** or **PerUnit**, then the **TimeUnit** parameter can be omitted. If included, it is ignored.

The example below expands on the previous example. In this example, after the Resources are created, the costs will be set. The example assumes that the CostTypes retrieved from the database are in the proper format. If this were not the case other logic would be required. Also, the time unit is retrieved for every cost type. However, as stated above, this field is ignored by **SetResourceCost** if it is not needed.

```
sql : STRING;
name : STRING;
units : REAL;
cost : REAL;
costType : STRING;
timeUnit : STRING;
sql := "Select Name, Units from Resource_Table where RunId=" +
       INTTOSTR(Model.RunId);
ReadFromDatabase(Model.Database, "Set", sql);
WHILE GetNext("Set")
  name := GetResult("Set", "Name");
  units := GetResult("Set", "Units");
  CreateResource(name, units, FALSE, FALSE, FALSE, FALSE);
  sql := Select Cost, CostType, TimeUnit from Cost_Table where
         Resource='" + name + "'";
  ReadFromDatabase(Model.Database, "CostSet", sql);
  WHILE GetNext("CostSet")
    cost := GetResult("CostSet", "Cost");
    costType := GetResult("CostSet", "CostType");
    timeUnit := GetResult("CostSet", "TimeUnit");
    SetResourceCost(name, cost, costType, timeUnit);
  END WHILE;
END WHILE;
```

SetResourceDowntime

A globally defined Resource Downtime (see "Global Resource Downtime" on page 344) can be applied to a Resource using the **SetResourceDowntime** command. As with **CreateResource**, **SetResourceDowntime** can only be used in the **Start Run** Expression. The full command is

```
SetResourceDowntime(ResourceName:STRING, DowntimeName:STRING);
```

The **ResourceName** parameter is the name of the Resource to which the **DowntimeName** will apply. Note that a global Downtime cannot be applied more than once to the same Resource.

The example below expands the previous example to include Downtime.

```
sql : STRING;
name : STRING;
units : REAL;
cost : REAL;
costType : STRING;
timeUnit : STRING;
downtimeType : INTEGER;
sql := "Select Name, Units from Resource_Table where RunId=" +
       INTTOSTR(Model.RunId);
ReadFromDatabase(Model.Database, "Set", sql);
WHILE GetNext("Set")
  name := GetResult("Set", "Name");
  units := GetResult("Set", "Units");
  CreateResource(name, units, FALSE, FALSE, FALSE, FALSE);
  sql := Select Cost, CostType, TimeUnit from Cost_Table where
         Resource='" + name + "'";
  ReadFromDatabase(Model.Database, "CostSet", sql);
  WHILE GetNext("CostSet")
    cost := GetResult("CostSet", "Cost");
    costType := GetResult("CostSet", "CostType");
    timeUnit := GetResult("CostSet", "TimeUnit");
    SetResourceCost(name, cost, costType, timeUnit);
  END WHILE;
  sql := Select DowntimeType from Downtime_Table where Resource='"
        + name + "'";
  ReadFromDatabase(Model.Database, "DTSet", sql);
  WHILE GetNext("DTSet")
    downtimeType := GetResult("DTSet", "DowntimeType");
    {DowntimeType of 0 indicates no downtime}
    IF downtimeType = 1
      SetResourceDowntime(name, "StandardShift");
    ELSIF downtimeType = 2
      SetResourceDowntime(name, "NightShift");
    END IF;
  END WHILE;
END WHILE;
```

SetResourceExpression

Expressions can be assigned to Resources created using **CreateResource** through the use of text files. The SIMPROCESS Expression Language code must be in a text file (ASCII) that is located in the model's directory. The code should be created and validated in SIMPROCESS before being saved to a file. The **SetResourceExpression** statement links a text file to a particular Resource Expression. The full command is

```
SetResourceExpression(ResourceName:STRING, ExpressionType:STRING,
ExpressionFile:STRING);
```

The **ResourceName** specifies the Resource to use. The **ExpressionType** must be **Start Simulation**, **Start Trial**, **Get Resource**, **Free Resource**, **Start Downtime**, **End Downtime**, **End Trial**, or **End Simulation**. **ExpressionType** is case sensitive. **ExpressionFile** is the complete name of the text file that contains the Expression code. No path is needed since the file must reside in the model's directory.

The example below expands the previous example to include Expressions. In this example, the proportion of time that the Resource is fully used needs to be determined. A global Resource Attribute named **MaximumUse** of type INTEGER has been defined. Time-weighted statistics were selected for the Attribute. In **getresource.txt** is the following code

```
IF UnitsBusy = Capacity
  MaximumUse := 1;
ELSE
  MaximumUse := 0;
END IF;
```

The following code is in **freeresource.txt**

```
MaximumUse := 0;
```

These files are used in the code below.

```
sql : STRING;
name : STRING;
units : REAL;
cost : REAL;
costType : STRING;
timeUnit : STRING;
downtimeType : INTEGER;
sql := "Select Name, Units from Resource_Table where RunId=" +
       INTTOSTR(Model.RunId);
ReadFromDatabase(Model.Database, "Set", sql);
```

```
WHILE GetNext("Set")
  name := GetResult("Set", "Name");
  units := GetResult("Set", "Units");
  CreateResource(name, units, FALSE, FALSE, FALSE, FALSE);
  sql := Select Cost, CostType, TimeUnit from Cost_Table where
         Resource='" + name + "'";
  ReadFromDatabase(Model.Database, "CostSet", sql);
  WHILE GetNext("CostSet")
    cost := GetResult("CostSet", "Cost");
    costType := GetResult("CostSet", "CostType");
    timeUnit := GetResult("CostSet", "TimeUnit");
    SetResourceCost(name, cost, costType, timeUnit);
  END WHILE;
  sql := Select DowntimeType from Downtime_Table where Resource='"
        + name + "'";
  ReadFromDatabase(Model.Database, "DTSet", sql);
  WHILE GetNext("DTSet")
    downtimeType := GetResult("DTSet", "DowntimeType");
    {DowntimeType of 0 indicates no downtime}
    IF downtimeType = 1
      SetResourceDowntime(name, "StandardShift");
    ELSIF downtimeType = 2
      SetResourceDowntime(name, "NightShift");
    END IF;
  END WHILE;
  SetResourceExpression(name,"Get Resource","getresource.txt");
  SetResourceExpression(name, "Free Resource",
     "freeresource.txt");
END WHILE;
```

Resource Usage

Since the Resources required for the model are not defined when the model is created, it is impossible to assign Resource usage on an Activity's **Resources** tab. Thus, the **`GetResource`** and **`FreeResource`** system methods must be used (page 281). The modeler must know which Activities will require Resources, but the modeler does not have to know which Resources will be required or the quantity of the Resources that will be required. For example the **Accept Entity** expression of the Activity could contain

```
GetResource(Entity.ResName, Entity.ResQuantity);
FreeResource(Entity.ResName);
```

where **ResName** is a STRING Entity Attribute containing the name of the Resource, and **ResQuantity** is a REAL or INTEGER Entity Attribute containing the number of units required. Most likely, the values of these Attributes would be set by an outside source.

Changing Resource Capacity With Expressions

IncreaseCapacity and **DecreaseCapacity** are system methods that will change the capacity of a Resource during a simulation run. "SIMPROCESS System Methods" on page 521 summarizes the methods. The methods apply to all Resources, whether consumable or not. Thus, **IncreaseCapacity** could be used to replenish a consumable Resource (however, the replenish to capacity option is not available). Just as with consumable Resources, the statistics for a Resource will reflect increases or decreases in capacity.

IncreaseCapacity

IncreaseCapacity can go in any type of Expression. When executed, it immediately increases the number of units of the Resources. The command is:

```
IncreaseCapacity("Resource1", 2);
```

The first parameter must be a String. It is the name of the Resource to increase. The second parameter must be an Integer or a Real. Even though the second parameter can be a Real, the number of units to increase cannot be fractional (even if the Resource is a fractional Resource).

DecreaseCapacity

Just like **IncreaseCapacity**, **DecreaseCapacity** can go in any type of Expression. When executed, it decreases the capacity of the Resource as units of the Resource become available. If the number of units to decrease are less than the number of units idle, then the decrease happens immediately. If not, then the capacity units are decreased as units go to idle. Note that if the request for decrease is larger than the current capacity, SIMPROCESS will reduce the capacity to zero. However, SIMPROCESS will keep track of the number of units not yet decreased. For example, if Resource1 has a capacity of 3, and the capacity is decreased by 4, then the capacity of Resource1 is zero. Then, if the capacity of Resource1 is increased by one, the capacity of Resource1 will still be zero. This is because there was one unit of decrease still not applied to Resource1. The full command is

```
DecreaseCapacity("Resource1", 2);
```

The first parameter must be a String. It is the name of the Resource to decrease. The second parameter must be an Integer or a Real. Even though the second parameter can be a Real, the number of units to decrease cannot be fractional (even if the Resource is a fractional Resource).

DecreaseCapacity is not a substitute for the consuming of consumable Resources. Consumable Resources will be consumed when released. It is not necessary to use a system method. **DecreaseCapacity** is intended for non-consumable Resources.

Setting Maximum Resource Wait With Expressions

The **Resources** tab of Activity properties dialogs allows a maximum wait time to be set (see "Adding Resource Requirements to Activities" on page 152). The maximum wait time is the maximum amount of time that an Entity will wait for the requested Resources to be acquired. The same thing can be accomplished using the Entity System Attribute **MaxWait** (see "System Attributes" on page 512). If the value for **MaxWait** is greater than zero, then the Entity will exit the Activity without processing if Resources have not been acquired by that time. Note that the time unit that applies to **MaxWait** is the **Simulation Time Unit** specified in the **Run Settings** (see "Run Settings" on page 109). If greater than zero, the **MaxWait** System Attribute overrides the **Value** set in the **Maximum Wait for Resource Time** section of the Resources tab of the Activity properties dialog. **MaxWait** must be set in the **Accept Entity** Expression. For example putting

```
Entity.MaxWait := .25;
```

in the **Accept Entity** Expression means that the Entity will wait at most .25 time units (if the **Simulation Time Unit** is Hours, then .25 represents .25 hours). The value for **MaxWait** must be reset to zero when a maximum wait for Resources is no longer needed. **MaxWait** is not reset automatically. It is best to set **MaxWait** to zero in the **Release Entity** Expression of the Activity where **MaxWait** was used.

```
Entity.MaxWait := 0.0;
```

When an Entity exits an Activity without processing, the Entity System Attribute **EndWait** is set to TRUE. Thus, **EndWait** can be checked to determine whether an Entity exited an Activity without processing and the Entity can be routed appropriately. **Important**: As with **MaxWait**, **EndWait** is not automatically reset to FALSE. This must be done in an Expression once the current value of **EndWait** is no longer needed for Entity routing.

```
Entity.EndWait := FALSE;
```

For Activities that collect statistics, Entity Counts for Entities that exit without processing are displayed in the **Total Not Processed** category of the Activity Entity Count statistics (page 196) in the Standard Report (page 186).

User-Defined Functions

A **User-defined Function** will return the value of an Expression each time it is called from within the model. This allows re-use of a single function in multiple places in the model. The value returned must be a real number.

To create a User-defined Function, go to the **Define** menu, and select **Functions**. This opens a list box displaying any previously defined Functions. The **Expression Editor** dialog opens for **Add**, **Edit**, and **Copy**. The **Name** of the function must be unique across all Functions, Standard distributions, Tabular distributions, and Auto Fits distributions. (See "User Defined Distributions," beginning on page 98 for information on defining Standard, Tabular, or Auto Fits distributions.)

The final line of the Expression should be a **RETURN** statement such as:

```
RETURN (Entity.Time * Activity.Factor);
```

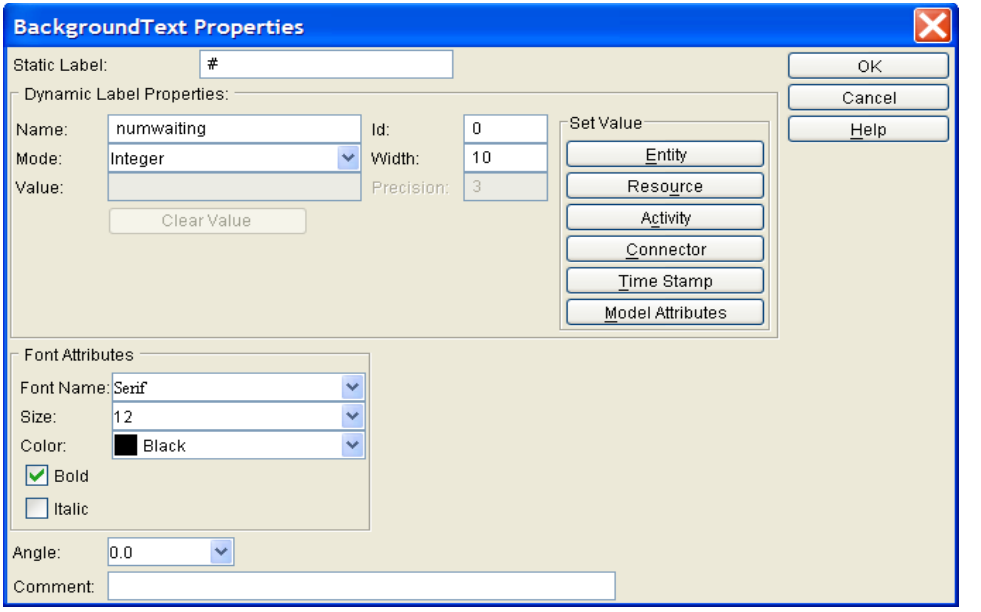
where **Entity.Time** and **Activity.Factor** are Attributes. Each time this Function is called, it will return the value of the multiple of the two Attributes. Note that only REAL or INTEGER values can be returned. Also, the value received by the caller is always a REAL even if an INTEGER value followed the **RETURN**.

The **Name** entered for the User-defined Function will appear in every combo box in the model where a statistical distribution can be entered. Also, User-defined Functions can be used in Expressions by using the **Function** system method. See "SIMPROCESS System Methods" on page 521.

The text of a Function can be stored in an external file. See "Expression Editor," beginning on page 259 for a discussion of that option.

Dynamic Labels

There are two types of background text in SIMPROCESS: static text and dynamic labels. Static text is used for annotating the model layout and does not change during simulation. Dynamic labels, as their name implies, are updated during simulation and are used to display information about changing properties of model elements. One way to update dynamic labels is through an **`UpdateDynamicLabel`** method in the Expression builder. (See "Background Text" on page 163 for a discussion of the other way to update dynamic labels.)



To update a dynamic label using Expressions, the dynamic label must have a unique combination of **Name** and **Id** number. Usually, **Id** number will be 0, unless two dynamic labels have the same **Name**. The name typed into the **Name** text box will not appear on the layout. It will only be used to reference the label from the Expression builder. The type of value with which the dynamic label will be updated must also be selected. The choice between String, Integer, and Real is made in the **Mode** combo box. If the value of the dynamic label is Real, **Width** and **Precision** must be specified in the corresponding value boxes. **Width** is the total number of digits that will be shown for the displayed value (including the decimal point), while **Precision** specifies the number of digits after the decimal point that will be displayed. If the **Width** is greater than the value being displayed, it will be padded with spaces on the left side. If the **Mode** is Integer, then only the **Width** field needs to be set.

Note that the **Value** field does not have to be empty to use **`UpdateDynamicLabel`**. The same dynamic label can be updated automatically and with **`UpdateDynamicLabel`**.

Once the dynamic label is defined, it can be updated by making a function call to the **`UpdateDynamicLabel`** method in the Expression builder. This method requires the following five arguments in this order:

`MasterEditor` — (typed as shown), reference to the main layout window.

`name` — a string (in quotes) used to designate the dynamic label in the **Name** text box of **Background Text** dialog. Make sure letter case is the same in both places.

`ID number` — the integer in the **Id** box of the **Background Text** dialog.

`text color` — a string (in quotes) of the color in which the text is to appear. A list of color names is found in "SIMPROCESS System Attributes and Methods," beginning on page 511. As with **`name`**, letter case must be as shown in the table. This overrides the font color selected in the properties dialog.

`value` — integer, real, or string value to display; type must correspond to what was selected in the **Mode** combo box of the **Background Text** dialog.

For example, to display a string showing the name of the Entity leaving a delay Activity, as well as a real value showing the amount of time this instance of an Entity spent at the Activity, and an integer showing number of Entities currently at that Activity, enter the following three commands in the Expression builder of the delay Activity at the Release Entity entry point:

```
UpdateDynamicLabel
    (MasterEditor,"num",0,"Orange",
    NumberIn);

UpdateDynamicLabel(MasterEditor,"name",0,
    "Aquamarine",Entity.Name);

UpdateDynamicLabel(MasterEditor,
    "lastdelay",0,"IndianRed",LastDelay);
```

For more information on Expression builder terminology and syntax, see "SIMPROCESS System Attributes and Methods," beginning on page 511.

Note that both dynamic and static text font Attributes can be changed during simulation by selecting the text and editing its properties. The change will take effect immediately after the **Background Text** dialog is closed and the simulation is resumed.

Interfacing With A Database

Expressions can retrieve information from an SQL database, and can modify an SQL database by inserting into tables, deleting from tables, and updating tables. Knowledge of SQL is required since all queries to the database are SQL queries. A sample model named **`DatabaseDemo.spm`** is part of the **`ExpressionDemos`** directory.

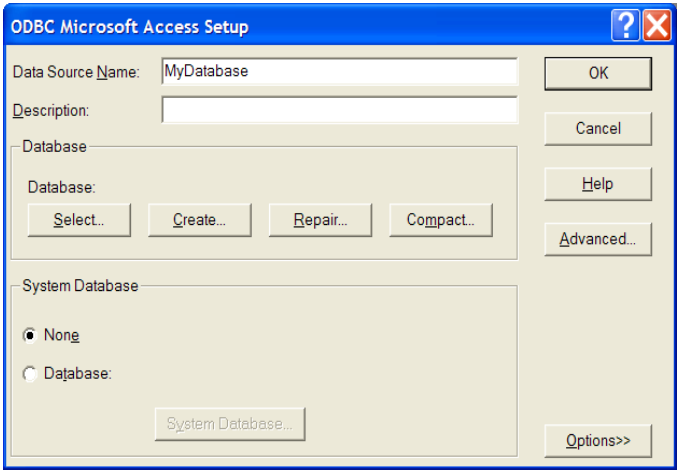
Setting Up Database Using Windows and Open Database Connectivity (ODBC)

When using Windows, the database must have a Data Source Name (DSN) specified in ODBC before SIMPROCESS can communicate with a database. Chapter 2 of the *Getting Started Manual* has detailed instructions on creating a DSN for the database that comes with SIMPROCESS. A similar procedure is followed for every database that is to communicate with SIMPROCESS in this way. However, instead of using the DSN **SimProcessDatabase** (which is for the database that comes with SIMPROCESS), another must be created. (Note, the **OpenDatabase** command on page 298 contains information on how to set up database connections for non-Windows systems.)

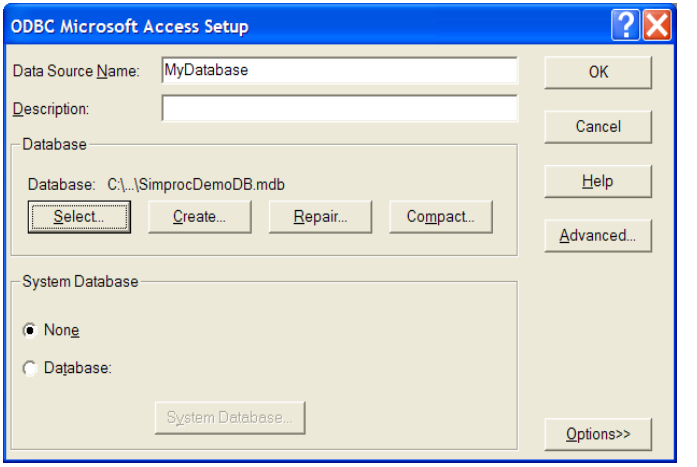
To create the DSN:

1. Open the ODBC control panel (on Windows 2000 and XP it is under the Administrative Tools control panel).
2. Select the **User DSN** tab and click on **Add**.
3. Select the appropriate driver for the database (for example, **Microsoft Access Driver**) and click **Finish**.

Clicking **Finish** brings up a dialog where the DSN is entered. The example below shows a DSN called **MyDatabase**.



Once a DSN has been entered, click the **Select** button. Browse to the location of the database, and, when found, click **OK**. The database will appear above the **Select** button.



Continue to click **OK** until ODBC is closed. The DSN created will be used by SIMPROCESS to communicate with the selected database. A unique DSN is required for every database that will interface with SIMPROCESS.

Database System Methods

There are six database-related System Methods which can be used in Expressions. (See "SIMPROCESS System Methods" on page 521.)

- OpenDatabase
- CloseDatabase
- ReadFromDatabase
- WriteToDatabase
- GetNext
- GetResult

OpenDatabase

OpenDatabase is used to create a connection between SIMPROCESS and a database. This must be done before any other database System Methods are used (the **Start Run** Expression is a good place to use it). Before using the method an Attribute must be defined (normally a Model Attribute) of type Object. (See "User Defined Attributes" on page 242.) This Attribute will be used as a reference to the database connection. The syntax for Windows with ODBC is

```
Model.ObjectAttribute := OpenDatabase("DSN", "UserName",
"Password");
```

where **DSN** is the **DSN** created in ODBC. **UserName** and **Password** are optional. These are only required if the database requires them for access.

Alternatively, a database properties file can be used. This file should be similar in content to the **sProcDB.properties** file in the **SPUser** directory. This file is used to connect SIMPROCESS to the database that comes with SIMPROCESS. (Note, do not modify **sProcDB.properties**. Copy the file before making changes.) A database properties file **must** be used when not using Windows and ODBC; however, a database properties file can be used with Windows and ODBC instead of the above procedure. Below is the contents of **sProcDB.properties**.

```
jdbc.drivers=sun.jdbc.odbc.JdbcOdbcDriver

jdbc.url=jdbc:odbc:SimProcessDatabase

jdbc.username=""

jdbc.password=""
```

Simply change each of the properties to reflect the protocols needed for the system. If using a database properties file with Windows and ODBC, the properties are the same except the end of the **url** property is the DSN set up in ODBC. When using a database properties file the syntax is:

```
Model.ObjectAttribute := OpenDatabase("PropertiesFileName");
```

where **PropertiesFileName** is the name of the database properties file. The preferred locations for a properties file are the model's directory or the **SPUser** directory. If not in one of those two locations, the **PropertiesFileName** must include the complete path to where it can be found.

If the connection is successful, the Attribute will contain a reference to the connection. Note that the connection is only valid for the model that created the connection. If another model needs to use the same database, that model must create its own connection.

CloseDatabase

CloseDatabase is used to close a connection to a database. This normally occurs at the end of a simulation (**End Simulation** or **End Run** Expression). The syntax is

```
CloseDatabase(Model.ObjectAttribute);
```

The only parameter is the Object Attribute that was used in the **OpenDatabase** system method that created the connection.

ReadFromDatabase

ReadFromDatabase gets information from a database and places the information into a **Result Set**. **GetNext** and **GetResult** are used to assign the data from a **Result Set** to Attributes or local variables in the model. The syntax is

```
ReadFromDatabase(Model.ObjectAttribute, "ResultSetName",
"SQLQuery");
```

Model.ObjectAttribute is the Object Attribute that was used in the **OpenDatabase** system method that created the connection. **ResultSetName** is a unique string identifier for the **Result Set** created by the query. **SQLQuery** is a string and is the query that creates the **Result Set**. Normally the query would start with the **SELECT** command.

WriteToDatabase

WriteToDatabase is used to modify the tables of the database. Nothing is returned. The syntax is

```
WriteToDatabase(Model.ObjectAttribute, "SQLQuery");
```

Model.ObjectAttribute is the Object Attribute that was used in the **OpenDatabase** system method that created the connection. **SQLQuery** is a string and is the query that modifies the tables of the database. This query can start with **INSERT**, **UPDATE**, or **DELETE**.

Note that **WriteToDatabase** can slow the simulation as table sizes increase. Also, be careful when

using **WriteToDatabase** if there is the possibility the simulation will be stopped early by user intervention. Updates to the database can lag behind the simulation. Thus, if the simulation is stopped early there is the potential that the **CloseDatabase** command would be executed before all the **WriteToDatabase** commands have finished. The consequence would be an error that could possibly crash SIMPROCESS. Omit the **CloseDatabase** command if this scenario might occur. If the **CloseDatabase** command is omitted, SIMPROCESS will not release the database until SIMPROCESS is closed.

GetNext

GetNext controls the position within a **Result Set**. **Result Sets** are simply tables of data. The columns are the fields requested in the SQL query. For instance, if the query was "**SELECT CallTime, WrapUpTime FROM Times**" the columns in the **Result Set** would be **CallTime** and **WrapUpTime**. **GetNext** sets the row of the **Result Set**. So **GetNext** is used in conjunction with **GetResult**. **GetResult** gets a value from the table (**Result Set**) once the row has been set. When a **Result Set** is first created by a **ReadFromDatabase**, the row pointer in a **Result Set** is pointing to before the first row. Thus, **GetNext** must be called before **GetResult**. The syntax is

```
BooleanVar := GetNext("ResultSetName");
```

BooleanVar is any Attribute or local variable defined to be a BOOLEAN. TRUE is returned if the next row exists, FALSE if not (at the end). **ResultSetName** is the user selected name given to a **Result Set** by a **ReadFromDatabase**.

Note that **GetNext** only moves forward through the rows. Going backwards is not possible. The only way to go back to the beginning of a **Result Set** is to execute again the **ReadFromDatabase** that created the **Result Set**.

GetResult

GetResult assigns a value from a **Result Set** to an Attribute or local variable in the model. The value comes from the current row of the **Result Set**. The current row is set by **GetNext**. The syntax is

```
Variable := GetResult("ResultSetName", "Field");
```

Variable can be an Attribute or a local variable. **ResultSetName** is the user-selected name given to a **Result Set** by a **ReadFromDatabase**. **Field** is the field from the database (column of the **Result Set**) that has the desired value.

The type of the value returned (INTEGER, REAL, BOOLEAN, or STRING) to **Variable** must match with the type of the **Variable**. Note that only INTEGER, REAL, BOOLEAN, and STRING values can be placed in a **Result Set**.

Database Example

The following are several examples on how to use the database System Methods. They are categorized by Expression type.

Start Simulation Example

This example assumes two real Model Attributes (**CallTime** and **WrapUpTime**) have been defined. Each of the Model Attributes have an array size that is equal to or larger than the number of values returned by the query. The values are placed in array Model Attributes because the values need to be referenced throughout the simulation. Also an object Model Attribute (**DatabaseConn**) was defined for the connection. Note that in the SQL query double quotes are required around the table name **Times Table** (for MS Access). Double quotes can be placed in strings by using \".

```
SQLString : STRING;
count : INTEGER;
Model.DatabaseConn := OpenDatabase("MyDatabase");
SQLString := "SELECT CallTime, WrapUpTime FROM \"Times Table\"
   WHERE Month = 12";
ReadFromDatabase(Model.DatabaseConn, "Times", SQLString);
count := 0;
WHILE GetNext("Times")
   Model.CallTime[count] := GetResult("Times", "CallTime");
   Model.WrapUpTime[count] := GetResult("Times", "WrapUpTime");
   count := count + 1;
END WHILE;
```

End Simulation Example

This example just shows closing a connection.

```
CloseDatabase(Model.DatabaseConn);
```

Accept Entity Example

In this example an Entity enters an Activity and gets its delay time from the database. This assumes the **WHILE** loop in the **Start Simulation** example was not performed.

```
SQLQuery : STRING;
IF GetNext("Times")
   Entity.Delaytime := GetResult("Times", "CallTime");
ELSE {will read again to start over if no more times are found}
   SQLQuery := "SELECT CallTime, WrapUpTime FROM \"Times Table\"
      WHERE Month = 12";
```

```
   ReadFromDatabase(Model.DatabaseConn, "Times", SQLQuery);
   IF GetNext("Times")
      Entity.Delaytime := GetResult("Times", "CallTime");
   END IF;
END IF;
```

Release Entity Example

This example shows writing to a database. The processing time of the Entity for the Process is placed in the database in a table named **ProcessTimes**. The simulation time the Entity entered the Process was stored in an Entity instance Attribute called **StartTime**.

```
SQLString : STRING;
time : REAL;
time := SimTime - Entity.StartTime;
SQLString := "INSERT Into ProcessTimes (ProcessTime) VALUES (" +
   REALTOSTR(time) + ")";
WriteToDatabase(Model.DatabaseConn, SQLString);
```

Interfacing With A Spreadsheet

Expressions can retrieve information from an Excel compatible spreadsheet, and can modify a spreadsheet by inserting new Worksheets, values, and formulas. A sample model named **`SpreadsheetDemo.spm`** is part of the **`ExpressionDemos`** directory.

Spreadsheet System Methods

There are four spreadsheet-related System Methods which can be used in Expressions. (See "SIMPROCESS System Methods" on page 521.)

- OpenSpreadsheet
- CloseSpreadsheet
- ReadFromSpreadsheet
- WriteToSpreadsheet

OpenSpreadsheet

`OpenSpreadsheet` is used to create a connection between SIMPROCESS and an Excel compatible spreadsheet file. This must be done before any other spreadsheet-related System Methods are used (the **Start Run** Expression is a good place to use it). Before using the method an Attribute must be defined (normally a Model Attribute) of type Object. (See "User Defined Attributes" on page 242.) This Attribute will be used as a reference to the spreadsheet. The syntax is

```
Model.ObjectAttribute := OpenSpreadsheet("Mode", "FileName");
```

where **Mode** is either **`Input`** or **`Output`**. A spreadsheet file cannot be open for both reading and writing at the same time. If **FileName** does not contain a path (the preferred method), the file's location will be the model's directory. If the **Mode** is **`Input`**, the file must already exist.

Two different file types are supported: Workbook files (which usually have the **`.xls`** extension) and Excel XML Spreadsheet files (which usually have the **`.xml`** extension). SIMPROCESS can only read from or write to Workbook files compatible with Excel 97 through Excel 2002. If the Workbook file was created with Excel 2003 or later, the Workbook must be saved as an XML Spreadsheet in order to read from or write to it from SIMPROCESS. When a spreadsheet is opened for **`Output`** and the file does not already exist, SIMPROCESS will create a Workbook file that is compatible with any of the latest versions of Excel. Also, the Workbook file is compatible with the Calc spreadsheet program in OpenOffice 1.1 (www.openoffice.org), widely used with Linux and other platforms. If a spreadsheet file opened for **`Output`** already exists and is an XML Spreadsheet, SIMPROCESS will retain that format.

CloseSpreadsheet

CloseSpreadsheet is used to close a spreadsheet file. (If opened for **Output**, the file's contents will be written at this time.) This normally occurs at the end of a simulation (**End Simulation** or **End Run** Expression). The syntax is

```
CloseSpreadsheet(Model.ObjectAttribute);
```

The only parameter is the Object Attribute that was used in the **OpenSpreadsheet** system method that created the connection.

ReadFromSpreadsheet

ReadFromSpreadsheet gets information from a spreadsheet and places the information into a local variable or Attribute. The syntax is

```
ReadFromSpreadsheet(Model.ObjectAttribute, "Worksheet", Row,
Column, Variable);
```

Model.ObjectAttribute is the Object Attribute that was used in the **OpenSpreadsheet** system method that created the connection. **Worksheet** is a string identifying the specific worksheet. **Row** and **Column** are INTEGER values that identify a particular cell of the **Worksheet** and both must be greater than or equal to one. **Variable** represents a local variable or an Attribute that will receive the value read from the spreadsheet. The **Variable** type (INTEGER, REAL, STRING, or BOOLEAN) must match the type of the value returned.

A run-time error will occur if the specified Worksheet does not exist, or if a cell at the specified Row and Column does not exist (a cell which contains no data is not considered to exist). Also, if the spreadsheet is a Workbook, a run-time error will occur if the requested cell contains a formula. In an XML Spreadsheet, the value calculated by the formula will be returned if it already exists in the file; if not, a run-time error will result.

WriteToSpreadsheet

WriteToSpreadsheet is used to modify a spreadsheet. Nothing is returned. The syntax is

```
WriteToSpreadsheet(Model.ObjectAttribute, "Worksheet", Row,
Column, Value);
```

Model.ObjectAttribute is the Object Attribute that was used in the **OpenSpreadsheet** system method. **Worksheet** is a string identifying the specific worksheet. **Row** and **Column** are INTEGER values that specify the particular cell of the **Worksheet** and both must be greater than or equal to one. **Value** is the value to be written to the specified cell. **Value** can have the type INTEGER, REAL, STRING, or BOOLEAN. If the requested Worksheet and/or cell do not exist, SIMPROCESS will create them. Formulas can be written to a spreadsheet. For

SIMPROCESS to recognize a formula, the **Value** parameter must be a STRING and must begin with "**=**" (e.g., "**=SUM(A1:A20)**"). Note that formulas written by SIMPROCESS will not produce a value in the cell until the spreadsheet has been opened in Excel or another compatible spreadsheet program.

Read and Write Cell References

Spreadsheet cell references in **ReadFromSpreadsheet** and **WriteToSpreadsheet** are based on **Row** and **Column** numbers. Thus when referring to a column, its alphabetic designation (e.g., the **A** in **A1**) must be changed to a numeric value, so that **A** becomes **1**, **B** becomes **2**, **C** becomes **3**, and so on. Also, the **A1** format is **Column**, **Row**, whereas **ReadFromSpreadsheet** and **WriteToSpreadsheet** use **Row**, **Column**.

Formula Cell References

As mentioned earlier, **WriteToSpreadsheet** can write formulas to a spreadsheet. There are two methods of referring to cells in formulas. The method used to construct formula strings in SIMPROCESS depends on whether the file being written to is a Workbook or an XML Spreadsheet.

In a Workbook, a **Row** value of 1 and **Column** value of 1 refers to the cell known as **A1** if editing in Excel or a compatible program. To write numeric data into cells A1 through A25 of a Workbook, the **WriteToSpreadsheet** statements must refer to rows 1 through 25 and column 1. But cell references in a formula used in the **WriteToSpreadsheet** statement for a Workbook take the same form as that used in Excel. So to write a formula in cell A27 containing the sum of cells A1 through A25, the necessary **WriteToSpreadsheet** statement would look similar to this:

```
WriteToSpreadsheet(Model.ObjectAttribute, "Worksheet", 27, 1,
"=SUM(A1:A25)");
```

When the resulting Workbook is opened in Excel, the formula bar would show the formula above in cell A27, and the cell itself would display the resulting numeric sum.

This type of cell reference is considered relative to the cell into which the formula is placed. Absolute cell references require the use of the **$** symbol, as in **=SUM($A$1:$A$25)**. The reasons for choosing absolute or relative cell references in Workbooks are beyond the scope of this manual, though either may certainly be used. As a reminder, **ReadFromSpreadsheet** cannot read from a cell containing a formula in a Workbook file and will produce a run-time error.

When writing to XML Spreadsheets, the **Row** and **Column** numbers must still be used in the formula strings. The **WriteToSpreadsheet** statement for placing this same **=SUM(A1:A25)** formula into row 27 and column 1 now becomes something similar to this:

```
WriteToSpreadsheet(Model.ObjectAttribute, "Worksheet", 27, 1,
"=SUM(R[-26]C:R[-2]C)");
```

The **R[-26]C** portion refers to a cell that is 26 rows above the one in which the formula appears. That is, its location is relative to that cell (at row 27, in the above example) and its row number can be discovered by adding the bracketed value **[-26]** to that row number, thus resulting in a row number of 1. The **C** portion refers to a column and is also an offset computed against the column number of the cell into which the formula is being written. An offset value of zero is usually omitted, but the column offset in this formula could also be written as **C[0]**. It is therefore possible to refer to any row and column by using appropriate offset values. And since this form is relative, the addition of rows and columns to the worksheet would cause the result of the formula's calculation to change.

As with the earlier Workbook formula example, the colon character indicates a range. The cell at the opposite end of the range is identified in the same manner as the first. In this example, the ending cell's row is the formula's row (27) added to the offset value (-2), or 25. The column number, just as with the previous reference, is the same as that of the formula (since an offset of zero is omitted).

If the resulting XML spreadsheet containing this formula were then opened in Excel, the formula bar would show the same thing for cell A27 as in the Workbook file: **=SUM(A1:A25)**. And the cell would display the same numeric result as the Workbook (assuming that both had the same values written into the cells being summed).

Absolute cell references are much easier to determine than the relative form when writing to XML spreadsheet files. A formula such as **=SUM(R1C1:R25C1)** uses absolute row and column number references, so that it too represents a formula that sums rows 1 through 25 of column 1. The key difference in this format is the lack of bracketed numbers, so that the values are absolute row or column number references rather than offset values based on the formula's cell location. Since absolute row and column numbers must be used here, each must have a value of one or greater.

As a reminder, when using **ReadFromSpreadsheet** to read a cell containing a formula from an XML spreadsheet, its value will be returned if present. However, when a formula is written as described above using **WriteToSpreadsheet**, the cell's new value will not be calculated until Excel or a compatible spreadsheet program opens the file, recalculates the formula result, and then saves the file to XML format with this new value in place. Any attempt to reopen the XML spreadsheet file for input and read from the cell before that has occurred would result in a run-time error.

Additional Spreadsheet XML Information

Much more information on the format of XML spreadsheets, formally known as SpreadsheetML (Spreadsheet Markup Language), is available from Microsoft. Among the complex topics discussed in that documentation are matters such as XML namespace usage and the additional capabilities of this file format. While it is possible to construct and manipulate these files using any tool that is fully

cognizant of the SpreadsheetML format and rules, there are some necessary limitations in what SIMPROCESS is able to handle. Some of these are listed below.

- When horizontal cell merging is used, the **`ReadFromSpreadsheet`** statement should correctly recognize this fact and locate a requested cell, if present. However, **`ReadFrom-Spreadsheet`** will not recognize vertically merged cells (i.e., those merged across multiple rows), and **`WriteToSpreadsheet`** will not respect any merging of cells. Excel or a compatible program may be unable to read the resulting XML file.
- Protection of any kind is not recognized. Using **`WriteToSpreadsheet`** will cause new worksheets or cells to be created if not present, regardless of any protection settings.
- Array formulas are not supported.
- Styles cannot be manipulated directly in SIMPROCESS. However, with the exception of those relating to protection, any styles already present in an existing XML spreadsheet file should not be affected by writing to the file using **`WriteToSpreadsheet`**.
- SIMPROCESS may have difficulty with any XML spreadsheet file that uses namespace prefixes in a way that differs from what appears in Microsoft's publicly available SpreadsheetML schema. The schema does not use prefixes on any of the elements of its XML. And it uses a small set of prefixes in a consistent manner on the attributes found on XML elements. XML which uses namespace prefixes on elements and uses different prefixes than those seen in the schema is perfectly valid, provided it is compliant with the schema. But upon opening any XML spreadsheet, Excel changes its namespace usage to match the form seen in the SpreadsheetML schema. That form is the only one SIMPROCESS currently supports. Therefore, the safest thing to do before allowing **`ReadFromSpread-sheet`** and **`WriteToSpreadsheet`** to operate on an XML spreadsheet file (if it may have been manipulated by any other program) is to open it in Excel and save it again. This usually has the additional side effect of recalculating any formulas present.
- The SpreadsheetML schema is complex and likely to continue evolving in the future. There may be other features which will not function correctly with SIMPROCESS.

Accessing Statistics During Simulation

There are times when it is useful to obtain the value of statistics during a simulation. For example, the value of certain statistics can be used to alter simulation flow, values can be placed into a user-defined database, or statistical values can be used in optimization. Any statistic collected during the simulation run can be accessed. This is done using various System Methods. (See "SIMPROCESS System Methods" on page 521.) There are nine System Methods for accessing statistics:

- GetActivityStatistic
- GetActivityByEntityStatistic
- GetAttributeStatistic
- GetCostStatistic
- GetEntityStatistic
- GetResourceStatistic
- GetResourceByActivityStatistic
- GetTimeStampStatistic
- GetTotalCostStatistic

The value of the statistic can be obtained for a specific replication, or the average or sum of replications can be obtained. The value of a specific replication can only be obtained if that replication has been run or is in the process of running. For example, the value for replication 2 is not available if replication 1 is the replication currently running. Also, the average and sum of replications are not available if only one replication is run. A value of -1 returns the average of replications, and a value of -2 returns the sum of replications.

GetActivityStatistic

`GetActivityStatistic` returns the value of a statistic for an Activity that has **Collect Activity Statistics** selected either globally or on the Activity properties. (See "Default Performance Measures" on page 186.) The syntax is

```
GetActivityStatistic("Activity Name", "Statistic", "Value Type",
Replication);
```

where **Activity Name** is the name of the Activity or Process, and **Statistic** is the statistic type desired. The key words for the statistics available are found in Appendix G. (See "Statistic Types" on page 586.) **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

GetActivityStatistic("Process4", "tokenlevel", "Avg", 1) returns the average number of Entities in Process4 for replication 1.

GetActivityStatistic("Process4", "tokendelay", "Max", 1) returns the maximum Entity cycle time for Process4 for replication 1.

GetActivityStatistic("Sales", "tokenwaitdelay", "Avg", -1) returns the average across replications of the Entity wait for Resources in the Activity "Sales".

GetActivityByEntityStatistics

GetActivityByEntityStatistic returns the value of a statistic for an Activity and that has **Collect Activity By Entity Statistics** selected either globally or on the Activity properties. (See "Default Performance Measures" on page 186.) The syntax is:

```
GetActivityByEntityStatistic("Activity Name", "Entity Name",
"Statistic", "Value Type", Replication);
```

where **Activity Name** is the name of the Activity or Process, **Entity Name** is the name of the Entity, and **Statistic** is the statistic type desired. The key words for the statistics available are found in Appendix G. (See "Statistic Types" on page 586.) All the statistic types for Activity by Entity statistics start with "by". **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

GetActivityByEntityStatistic("Process4", "Sales Calls", "bytoken.delay", "Avg", -1) returns the average cycle time across replications of the Entity "Sales Calls" in the Process "Process4".

GetActivityByEntityStatistic("Process4", "Sales Calls", "bytokenin", "Max", 2) returns the number of "Sales Calls" Entities that entered the Process "Process4" in replication 2. Although other Value Types are available, the maximum value is the value of interest since the number of Entities entering are just counted.

GetAttributeStatistic

GetAttributeStatistic returns the value of an Attribute that is being monitored for statistics. On the Attribute properties either **Observation Based** or **Time-Weighted** must be selected for **Statistics Types**, and at least one of the **Report Requests** must be selected. (See "Globally Defining an Attribute from the Menu" on page 243.) The value returned will be based on the **Statistic Type** selected on the Attribute properties (**Observation Based** or **Time-Weighted**). The Attribute name must be unique among

the user-defined Attributes that are being statistically monitored. The syntax is:

`GetAttributeStatistic("Attribute Name", "Value Type", Replication);`

where **Attribute Name** is the name of the Attribute. **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

`GetAttributeStatistic("ProcessingTime", "Avg", 1)` returns average value for the Attribute "ProcessingTime" for replication 1.

`GetAttributeStatistic("ProcessingTime", "Max", -1)` returns maximum value across replications (that is, the maximum of the averages for each replication) for the Attribute "ProcessingTime".

GetCostStatistic

`GetCostStatistic` returns the Capacity or Absorption cost of a cost period. (See “Setting Up Cost Periods” on page 179.) The syntax is:

`GetCostStatistic("Period Name", "Cost Object 1", "Cost Object 2", "Cost Type", "Value Type", Replication);`

where **Period Name** is the name of the period, **Cost Object 1** is the name of the first cost object, **Cost Object 2** is the name of the second cost object, and **Cost Type** is either "Capacity" or "Absorption". **Cost Object 1** can either be a Resource name or an Activity name. **Cost Object 2** can either be an Activity name or an Entity name. Thus, the possible combinations of **Cost Object 1** and **Cost Object 2** are "Resource Name, Activity Name", "Resource Name, Entity Name", or "Activity Name, Entity Name". **Value Type** can be "Avg", "StDev", "Min", or "Max" for **Replication** -1. If **Replication** is 1 or greater, the maximum value is returned no matter what is entered for Value Type.

Some examples:

`GetCostStatistic("Week1", "Sales Rep", "Sales", "Capacity", "Max", -1)` returns the maximum Resource by Activity capacity cost across replications for the cost period "Week1". "Sales Rep" is a Resource, and "Sales" is an Activity.

`GetCostStatistic("Week1", "Sales Rep", "Sales Calls", "Capacity", "Min", -1)` returns the minimum Resource by Entity capacity cost across replications for the cost period "Week1". "Sales Rep" is a Resource, and "Sales Calls" is an Entity.

`GetCostStatistic("Week1", "Sales", "Sales Calls", "Absorption",`

"Avg", 1) returns the Activity by Entity absorption cost for replication 1 for the cost period "Week1". "Sales" is an Activity, and "Sales Calls" is an Entity. Since this is the value for a replication, the maximum value is returned even though "Avg" is the **Value Type**.

GetEntityStatistic

GetEntityStatistic returns the value of a statistic for an Entity that has **Collect Entity Statistics** selected either globally or on the Entity type properties. (See "Default Performance Measures" on page 186.) The syntax is

```
GetEntityStatistic("Entity Name", "Statistic", "Value Type",
Replication);
```

where **Entity Name** is the name of the Entity, and **Statistic** is the statistic type desired. The key words for the statistics available are found in Appendix G. (See "Statistic Types" on page 586.) **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

GetEntityStatistic("Sales Calls", "tokentotalborn", "Max", 1) returns the total number of "Sales Calls" Entities that were generated in replication 1.

GetEntityStatistic("Sales Calls", "tokendelay", "Avg", -1) returns the average "Sales Calls" cycle time across replications.

GetEntityStatistic("Sales Calls", "tokenholdlevel", "Max", 1) returns the maximum number of "Sales Calls" Entities that were in a hold condition for replication 1.

GetResourceStatistic

GetResourceStatistic returns the value of a statistic for a Resource that has **Collect Resource Statistics** selected either globally or on the Resource properties. (See "Default Performance Measures" on page 186.) The syntax is:

```
GetResourceStatistic("Resource Name", "Statistic", "Value Type",
Replication);
```

where **Resource Name** is the name of the Resource, and **Statistic** is the statistic type desired. The key words for the statistics available are found in Appendix G. (See "Statistic Types" on page 586.) **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

GetResourceStatistic("Sales Rep", "resrcidle", "Avg", -1) returns the average number of "Sales Rep" units idle across replications.

GetResourceStatistic("Sales Rep", "resrcbusy", "Max", 1) returns the maximum number of "Sales Rep" units busy for replication 1.

GetResourceByActivityStatistic

GetResourceByActivityStatistic returns the value of a statistic for a Resource that has **Collect Resource By Activity Statistics** selected either globally on the Resource properties. (See "Default Performance Measures" on page 186.) The syntax is:

```
GetResourceByActivityStatistic("Resource Name", "Activity Name",
"Value Type", Replication);
```

where **Resource Name** is the name of the Resource, and **Activity Name** is the name of the Activity. **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

GetResourceByActivityStatistic("Sales Rep", "Sales", "Avg", -1) returns the average number of "Sales Rep" units busy at Activity "Sales" across replications.

GetResourceByActivityStatistic("Sales Rep", "Sales", "Max", 1) returns the maximum number of "Sales Rep" units busy at Activity "Sales" for replication 1.

GetTimeStampStatistic

GetTimeStampStatistic returns the value of a time stamp that has either **Collect Statistics**, Real-Time Trace Plot, or Real-Time Histogram Plot selected on the time stamp definition. (See "Time Stamps" on page 201.) The syntax is:

```
GetTimeStampStatistic("Start Key", "Stop Key", "Value Type",
Replication);
```

where **Start Key** is the starting key of the time stamp, and **Stop Key** is the stopping key of the time stamp. **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

GetTimeStampStatistic("start", "stop", "Avg", -1) returns the average of the time stamp with the start key "start" and stop key "stop" across replications.

GetTimeStampStatistic("start", "stop", "Count", 1) returns the number of observations of the time stamp with the start key "start" and stop key "stop" for replication 1.

GetTotalCostStatistic

GetTotalCostStatistic returns the total Capacity or Absorption cost of a Resource, Entity, or Activity. The syntax is:

```
GetTotalCostStatistic("Name", "Cost Type", "Value Type",
Replication);
```

where **Name** is the name of the Resource, Entity, or Activity. If the **Name** is "Total", the value returned is for all Resources. **Cost Type** is "Capacity" or "Absorption". **Value Type** can be "Avg", "StDev", "Min", or "Max" for **Replication** -1. If **Replication** is 1 or larger, the maximum value is returned no matter what is entered for **Value Type**.

Some examples:

GetTotalCostStatistic("Sales Rep", "Absorption", "Max", 1) returns the total absorption cost of the "Sales Rep" Resource for replication 1.

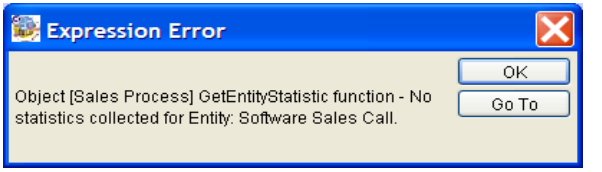
GetTotalCostStatistic("Customer", "Capacity", "Max", 1) returns the total capacity cost of the "Customer" Entity for replication 1.

GetTotalCostStatistic("Total", "Absorption", "Max", 1) returns the total absorption cost of all Resources for replication 1.

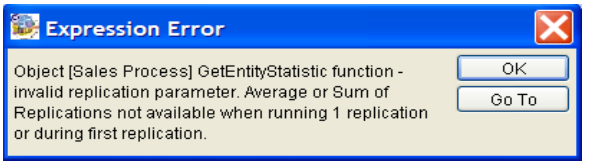
GetTotalCostStatistic("Total", "Capacity", "Avg", -1) returns the average total capacity cost of all Resources across replications.

Statistic Errors

If the statistic requested is not found, a run time error will occur. This will occur if a statistic is requested for which no statistics collection was defined. In the following example no statistics were collected for the Entity "Sales Calls".



Another common error is to request the average of replication statistics when only one replication was run or when the first replication is running. The average of replication can be requested during the simulation of replication 2 or higher, or after all replications have been completed. In the following example the average of replications (-1) was requested during the simulation of replication 1.



Requesting the statistic for a replication that is not currently running or has not yet run will not cause an error. The value zero will be returned.

Creating and Controlling Plots With Expressions

There are five System Methods for plotting listed in "SIMPROCESS System Methods" on page 521: `CreatePlot`, `AddPlotLegend`, `ClearPlot`, `DisplayPlot`, and `PlotValue`. These methods give the modeler complete control over plots. As with all other plots, plots created through expressions are saved automatically in the **`SPUser/plots`** directory. The code examples show below and the two plots at the end of this section are from the SIMPROCESS demonstration model **`SplitJoin.spm`**. Also, **`ExpressionPlots.spm`** is in the **`ExpressionDemos`** directory.

CreatePlot

This method creates a Trace or a Histogram plot. The syntax is

`Model.ObjectAttribute := CreatePlot(Type, Title, X Axis Label (Optional), Y Axis Label (Optional);` where **`Type`** is "Trace" or "Histogram".

This method returns the created plot to an Attribute with a **`Mode`** of Object. (See "Creating a User Defined Attribute" on page 242.) All parameters must be of type STRING. Even though the axis labels are optional, there must be an **`X Axis Label`** if there is a **`Y Axis Label`**. Use **`""`** for the **`X Axis Label`** to only label the Y axis. Note that this method does not cause the plot to display. Just as with plots defined from the **`Report`** menu, Expression Plots can be populated before being visible. Unlike menu defined trace plots, the X axis cannot be a date axis.

```
Model.ProcessTimeTrace := CreatePlot("Trace", "Entity Processing Time Trace", "Replication", "Time in Minutes");
Model.ProcessTimeHistogram := CreatePlot("Histogram", "Entity Processing Time Histogram", "Time in Minutes", "Number");
```

AddPlotLegend

This method adds a legend to a plot. The syntax is

```
AddPlotLegend(Model.ObjectAttribute, Dataset, Label, Color (Optional));
```

The first parameter is the Object Attribute that points to the appropriate plot. **`Dataset`** is an INTEGER (beginning with 0) that represents the set of data to which this legend applies. Thus, multiple data sets can be plotted on the same graph. **`Label`** is a STRING and is the text of the legend. If used, **`Color`** must be a STRING, and the **`Color`** must be one of the ones listed in the "SIMPROCESS Color Table" on page 576. If **`Color`** is not used, the plot will automatically assign a color to the legend and data

set. Note that legends will appear on the plot in the order in which the **AddPlotLegend** methods are executed.

```
AddPlotLegend(Model.ProcessTimeTrace, 0, "Orders", "Blue");
AddPlotLegend(Model.ProcessTimeTrace, 1, "Invoice", "Green");
AddPlotLegend(Model.ProcessTimeHistogram, 0, "Orders", "Blue");
AddPlotLegend(Model.ProcessTimeHistogram, 1, "Invoice", "Green");
```

ClearPlot

This method removes all data from a plot. The syntax is

ClearPlot(Model.ObjectAttribute); where Model.ObjectAttribute is the Object Attribute that points to the appropriate plot.

DisplayPlot

This method causes a plot to be visible. The syntax is

```
DisplayPlot(Model.ObjectAttribute);
```

The parameter is the Object Attribute that points to the appropriate plot. There is no error if the method is executed and the plot is already visible. Plots can also be displayed by using the **Report** menu (**Report/ Display Real-Time Plots**) or the **Display Plots** button on the tool bar.

```
DisplayPlot(Model.ProcessTimeTrace);
DisplayPlot(Model.ProcessTimeHistogram);
```

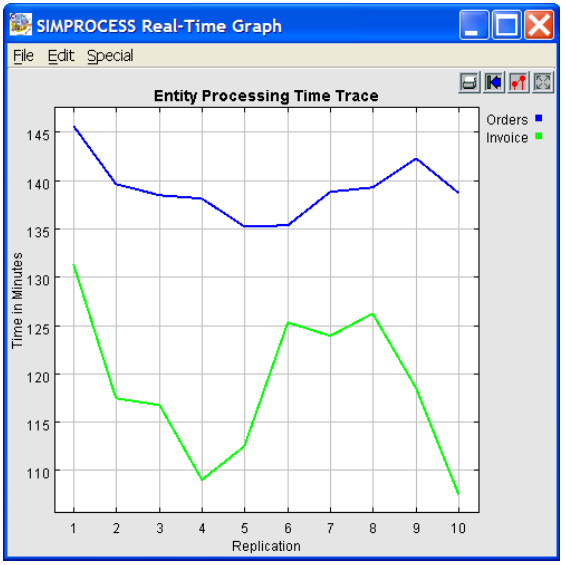
PlotValue

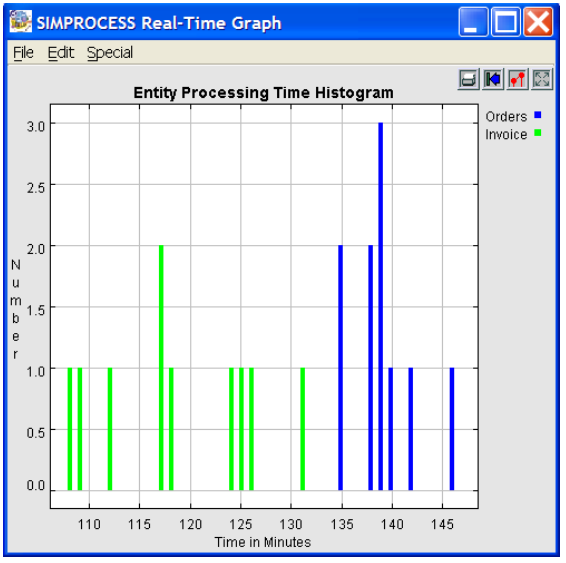
The method adds a data point to a plot. The syntax is

```
PlotValue(Model.ObjectAttribute, Dataset, X Value, Y Value (Trace
only));
```

The first parameter is the Object Attribute that points to the appropriate plot. **Dataset** is an INTEGER (beginning with 0) that represents the set of data to which this data point belongs. **X Value** and **Y Value** can be INTEGER or REAL. Both values are required for Trace plots. Only the **X Value** is used with Histogram plots.

```
PlotValue(Model.ProcessTimeTrace, 0, Replication, OrderTime);
PlotValue(Model.ProcessTimeTrace, 1, Replication, InvoiceTime);
PlotValue(Model.ProcessTimeHistogram, 0, OrderTime);
PlotValue(Model.ProcessTimeHistogram, 1, InvoiceTime);
```





Summary

This chapter described how Attributes are used in SIMPROCESS, and introduced Expression processing with a step-by-step example. The following was discussed:

- *Attributes* are variables of model elements whose value can change during a simulation run.
- *System* Attributes are those built in to SIMPROCESS. *User Defined Attributes* are custom-defined by users.
- *Object* Attributes identify the model element whose Attribute is being referenced.
- *Globally-defined* user Attributes are created for every model element of the same class (Activities, Resources, etc.).
  Locally-defined Attributes apply only to a single type of a model element.
- *Expressions* are user-written procedures which are invoked by SIMPROCESS at various events during a simulation run. An introduction to the basics of this language begins on page 254.
- *Object Attributes* are used in Expressions to qualify Attribute references.
- Numerous *System Methods* are available to add functions to Expressions.

CHAPTER 11

More Advanced Model Building

This chapter discusses the advanced schedules of the Generate activity and Resource downtime. Most real world scenarios do not operate at the same schedule 24 hours per day, 365 days per year. Thus, the ability to vary entity generation and the availability of resources is critical.

Defining a More Complex Generate Activity

A Generate Activity generates different types of Entities, or it can vary the schedule of entity generation for a single entity type.

Specifying the Active Period of Entity Release

The period that the entity release schedule is in effect can be limited by specifying Release *Start* and *End* dates. To do this, click on the **Start/End** tab and specify the **Start** and **End** dates.

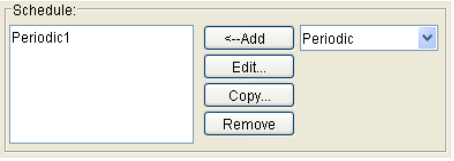
If **Start** and **End** dates are specified, the Generate Activity will not produce Entities outside of that time period.

The **Start** and **End** dates work in conjunction with the Start Date and End Date of a simulation run. So keep in mind that, if the simulation run dates are entirely outside of the period defined for the Generate release schedule, no Entities are generated during that simulation.

If a *Generation Start* date is not specified, SIMPROCESS sets the Start time to correspond to simulation start time. Similarly, if *Generation End* date is blank, it defaults to the simulation end time. So leaving the Generation **Start/End** fields blank ensures that the schedule is in effect for the entire simulation run.

Defining Schedules for a Generate Activity

The Generate schedule identifies the entity-generation pattern defined for an Activity. When a new schedule item is defined, it is added to the **Schedule** list box:



Each **Schedule** identifies an entity generation pattern of a specific type:

- **Periodic**: A periodic schedule generates a specified quantity of Entities at the end of a specified time period
- **Calendar**: Generates Entities according to a calendar schedule: daily, weekly, monthly, etc.
- **Weekly**: A schedule that allows generation intervals for every day of the week. This schedule differs from a Calendar Weekly schedule. See description below for details.
- **Cyclical**: A detailed sequence of when Entities are generated
- **File**: A schedule defined in an external file

- **Spreadsheet**: A schedule defined in an external spreadsheet
- **External**: Generates Entities based on inputs from an external source. External schedules are a plug-in capability that can be licensed separately from CACI.

Schedules are processed in parallel. If there are two schedules that overlap in time, SIMPROCESS processes both simultaneously.

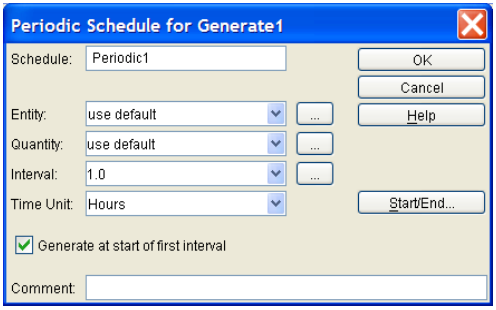
Click on **Add** to define a new schedule, or **Edit** to change the definition of the item highlighted in the schedules list box. When adding a new schedule, first identify the type of entity generation pattern by selecting from the **Schedule Type** combo box.

Copy duplicates the definition of the item highlighted in the **Schedule** list box. Use this when two or more similar schedules are needed.

Remove deletes the highlighted schedule.

Adding a Periodic Schedule

The Periodic schedule defines a constant or statistical distribution of entity generation events per period:



The **Periodic Schedule** dialog contains the following items:

Schedule: Assign a meaningful name to the entity generation schedule. The default name assigned by SIMPROCESS is the same as the schedule type; in this case, **Periodic1**.

Entity specifies the type of entity to be generated by this schedule. **Use default** tells SIMPROCESS to generate the type of entity indicated in the **Generate Activity Properties** dialog. To specify a different type, click on the pull-down arrow for a list of entity types to choose from.

Quantity is the number of Entities to be produced at each entity generation by this schedule. Again, **use default** refers back to the value in the **Generate Activity Properties** dialog. See page 75 of the

SIMPROCESS User's Manual for additional details on this field.

Interval defines the time between entity-generation events for this schedule.

Start/**End** defines the effective period for this schedule.

The times in the **Start** and **End** fields apply just to this schedule. The **Start** and **End** dates for the schedule must be within the **Start** and **End** dates specified on the **Generate Activity Properties** dialog. If a date is not entered for either **Start** or **End**, the corresponding value (if any) in the **Generate Activity Properties** applies.

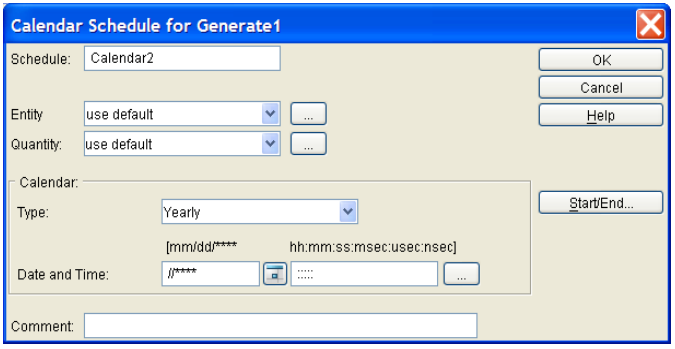
Count Limit sets the maximum number of Entities that can be generated by this schedule. A **Count Limit** value of 0 indicates that there is no limit.

If the **Count Limit** is reached, the Generate Activity may stop generating Entities for this schedule. This depends on the setting of the **Both must be reached** and **Generation End** fields.

Both must be reached specifies that both the **Count Limit** and **Release End** date must be attained in order to terminate entity generation for this schedule. If the **Both must be reached** field is not marked, then reaching either **Generation End** or **Count Limit** terminates the schedule.

Adding a Calendar Schedule

To add a schedule that generates Entities based on the calendar, select **Calendar** under **Schedule Type** on the **Generate Activity Properties** dialog, and then click on **Add**:



The following types of entity-generation schedules can be specified in the **Calendar Schedule** dialog:

- **Yearly** - Entities are generated once every year, on a particular date
- **Monthly** - Entities are generated on a specific day in each month (e.g., 1st of the month)

- **Weekly** - A certain time of day, on the specified day of the week (e.g., Monday, Tuesday...)
- **Daily** - Every day, generated at the specified time
- **Hourly** - Every hour, generated at the specified time
- **Date** - A specific date and time. This event will occur only once, at the specified date and time.

The **Calendar Schedule** dialog changes in appearance depending on the **Type** of schedule selected:

- If **Calendar Type** is **Weekly**, a list of the days of the week is added to the dialog.
- The heading above the **Date and Time** field changes to prompt for the information required for the **Type** schedule selected.

For example, if a **Daily** entity generation schedule is selected, a time of day must be entered in the **Date and Time** field.

Any information that does not apply to a **Daily** schedule, such as the date and year, is ignored.

As with all schedules, **Start/End** can be used to further define the effective period for a Calendar generation schedule.

Adding a Weekly Schedule

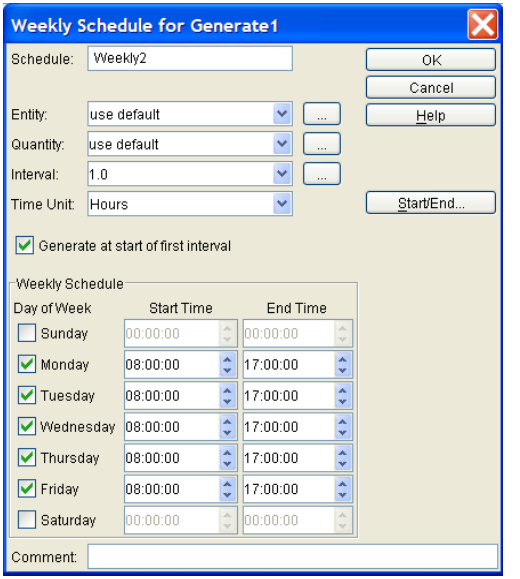
A Weekly schedule is similar to a Periodic schedule in that the schedule defines a constant or statistical distribution of entity generation events. The difference is that the Weekly schedule allows the entity generation events to be restricted to certain days of the week and certain time periods of the day. Note that this Weekly schedule is different from a Calendar Weekly schedule. A Calendar Weekly schedule only generates a certain quantity of entities once a week on a specified day and time. This Weekly schedule generates multiple times based on a periodic interval restricted to certain days and times. To add a Weekly schedule, select **Weekly** under **Schedule Type** on the **Generate Activity Properties** dialog, and then click on **Add**.

See the Periodic schedule definition (page 321) for information on **Schedule**, **Entity**, **Quantity**, **Interval**, **Time Unit**, and **Start/End**.

Use the **Weekly Schedule** portion to select each **Day of Week** for which the **Entity**, **Quantity**, and **Interval** apply. When a **Day of Week** is selected, the **Start Time** and **End Time** for that day activate. Enter the **Start Time** and **End Time** for entity generation for that **Day of Week**. If both **Start Time** and **End Time** show 00:00:00, entity generation will occur for the complete day (24 hours). If **End Time** shows 23:59:59, it is assumed that 00:00:00 for the next day is intended, and the final second will be added to the entity generation period.

If the **Generate at start of first interval** check box is selected, an entity will be generated at the **Start Time**

of each active **Day of Week**. If the check box is not selected, a random value based on the **Interval** and **Time Unit** will be added to the **Start Time** for the first entity generation of each active **Day of Week**.



Defining Cyclical Schedules

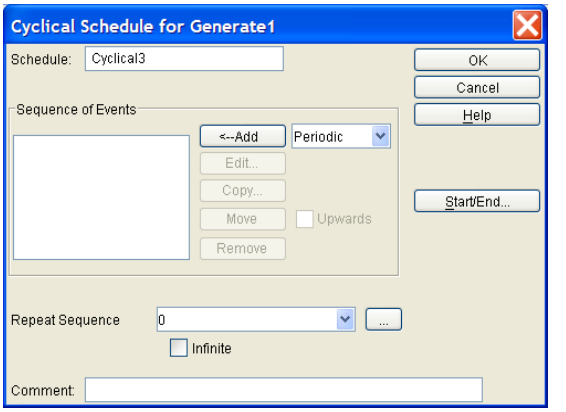
Use the cyclical schedule to define a detailed sequence of entity generation cycles. For example, a week day-by-day, or a year month-by-month could be described. A unique period such as the holiday rush leading up to Christmas could be defined, where entity generation behavior differs markedly from the rest of the year.

A cyclical schedule is defined as a series of *cycles*. Each cycle describes a different entity generation sequence. In a sense, the cycle series is like a schedule of its own. But unlike the schedules defined for the Generate Activity as a whole, cycle events are processed *sequentially*, not in parallel. Since one cycle follows another, order is important. Cycles can be repeated as many times as is needed.

The following types of cycles can be defined:

- **Periodic**. A constant or statistical distribution defining the time interval between events
- **Calendar**. Entity generation events scheduled at intervals based on the calendar, i.e., weekly, monthly, etc.
- **Single Event**. A one-time entity generation event

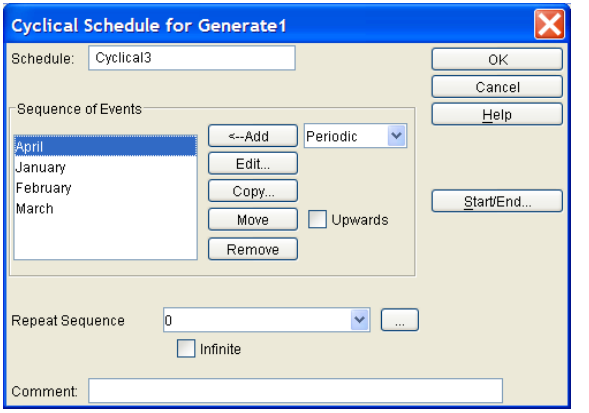
- **No Event**. A period where no Entities are generated
- **Cyclical**. A cycle within a cycle; that is, a more detailed breakdown within a schedule (e.g., the various periods within a single day — breakfast, meeting, coffee break, lunch — within a workweek described day-by-day).



Cycles are added to and modified from the **Cyclical Schedule** dialog.

The **Sequence of Events** dialog lists the cycle events defined for this cyclical schedule. The events are listed in the order in which SIMPROCESS will execute them. When a cycle is added, SIMPROCESS places it at the end of the list. The pattern can be rearranged using the **Move** command.

For example, here is a list of cycles defined out of sequence:



To move the April cycle to the end of the list, highlight April and click on the **Move** button three times.

Each click of **Move** shifts the item down a row.

Cycles can be moved up in the list by checking the **Upwards** option before clicking the **Move** button.

Repeat Sequence tells SIMPROCESS how many times to *repeat* execution of the pattern of cycles. If **Infinite** is checked, SIMPROCESS will keep repeating the cycle pattern until **Generation End** is reached.

Note about Repeat Sequence

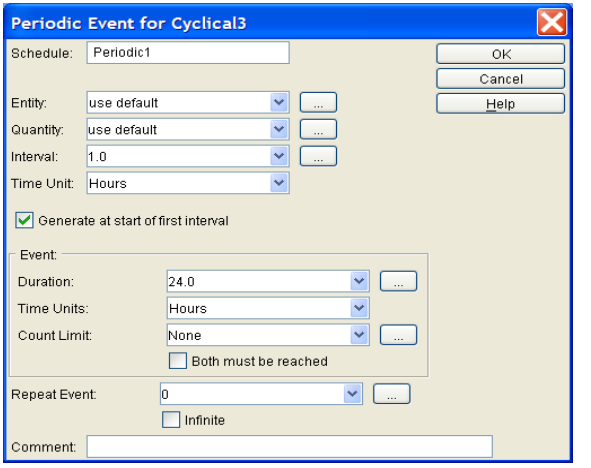
A value of *0* in the **Repeat Sequence** field tells SIMPROCESS to run through the list a single time, without repeating it. A value of 1 results in two passes through the **Sequence of Events**: the initial run-through and one repetition.

Do not confuse the number of *repetitions* with the number of *passes* through the list.

Refer to page 322 for a description of the **Start**/**End** option.

Defining a Periodic Cycle

A periodic cycle defines a constant or statistical distribution of entity generation events. To define a periodic cycle in a cyclical schedule, select **Periodic** from the list of **Schedule** types, and then click on **Add**:



Defining a periodic cycle is similar to defining a periodic schedule (see page 321). The major difference is that duration of the cycle is not defined in terms of start and end dates. That is because the start time is under the control of the cyclical schedule of which the cycle is a part:

Duration is how long this cycle is in effect. A number can be entered or a value selected from the pull-down list for this field. **Time Units** specifies the time unit of the **Duration**.

The starting time of the event is determined by the following factors:

- The **Generation Start** date of the cyclical schedule
- The position of this cycle in the **Schedule of Events** in the **Cyclical Schedule** detail dialog
- The **Duration** of the cycles that precede this one.

Count Limit sets a maximum number of Entities that may be generated during this cycle. A value of *0* indicates no limit.

The **Both must be reached** checkbox, if marked, specifies that both the **Duration** and **Count Limit** must be reached before the cycle completes.

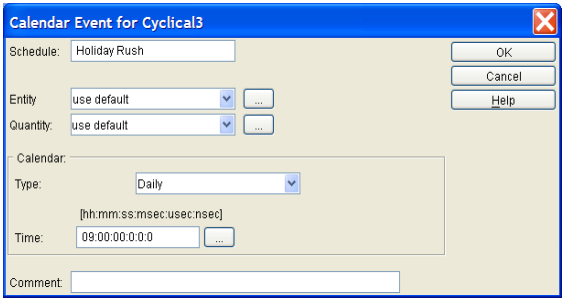
Note that selecting **Both must be reached** can result in a cycle of unknown duration. This happens if the **Count Limit** is not reached before the end of the **Duration** period. In that event, the cycle continues until either the **Count Limit** is attained, or the Generate Activity **Generation End** is reached.

Repeat Event tells SIMPROCESS how many times to repeat execution of this cycle. If **Infinite** is selected, SIMPROCESS will keep repeating the cycle until the schedule's **Generation End** date is reached.

- The **Entity, Quantity**, and **Interval** fields are used the same way they are in the **Periodic Schedule** detail dialog (see page 321).

Defining a Calendar Cycle

A calendar cycle defines entity generation events that repeat on either a daily, weekly, monthly, or yearly basis:



The dialog above shows a calendar cycle representing four days leading up to a festive holiday, when people are rushing to buy gifts for their loved ones. It's a daily schedule, beginning at 9 a.m. Note that there is no duration on calendar events. They will operate as long as possible. For the example above, since it is a Daily schedule, it will generate every day at 9 o'clock. Thus, any events listed after the Daily event in the Cyclical schedule will not execute, since the Daily event will keep generating.

As with the periodic cycle, the start time of a calendrical event is determined by the cyclical schedule in which the cycle is defined. However, *entity generation* is not triggered until the time that is indicated in the **Date and Time** field. If the trigger point is not reached while the cycle is in effect, no Entities are generated. For a further explanation, see "SIMPROCESS' Scheduling of Event Cycles" on page 328.

The **Date and Time** needed depends on the **Calendar Type** schedule selected:

- **Yearly**. Enter a date and time of day, but do not specify a year. Entity generation begins if the simulation reaches the specified date and time during this cycle.
- **Monthly**. Specify a day of the month and time of day, e.g., the first of the month, at noon. Entity generation begins if the simulation reaches the specified day and time while the cycle is in effect.
- **Weekly**. Select a day of the week (from a list that appears when **Weekly** is checked off) and a time of day. Entity generation begins if the simulation reaches that day and time during the cycle.
- **Daily**. Specify a time of day. Entities are released if the simulation reaches this time of day while the cycle is in effect.
- **Hourly**. Specify the minutes and seconds of an hour. Entities are released if the simulation reaches this time of day while the cycle is in effect.
- **Date**. Specify a specific date and time. Entities are released if the simulation reaches this date and time while the cycle is in effect.

SIMPROCESS' Scheduling of Event Cycles

Calendar cycles must be carefully placed within the **Sequence of Events**. If the trigger time specified in the **Date and Time** field has already passed when SIMPROCESS invokes a cycle, entity generation may not occur.

For example, assume a cyclical schedule with a **Generation Start** date of January 1, 2004, and a **Generation End** date of March 31, 2004. The schedule contains the following **Schedule of Events** cycles:

- A periodic cycle event beginning on January 1, with a duration of 48 hours.
- A calendar cycle which is triggered monthly, on the 2nd of the month.

The simulation begins at midnight, January 1. The periodic cycle starts right away and lasts for 48

hours. At this point it is midnight, January 3rd, and the calendar cycle is implemented. What happens during this period?

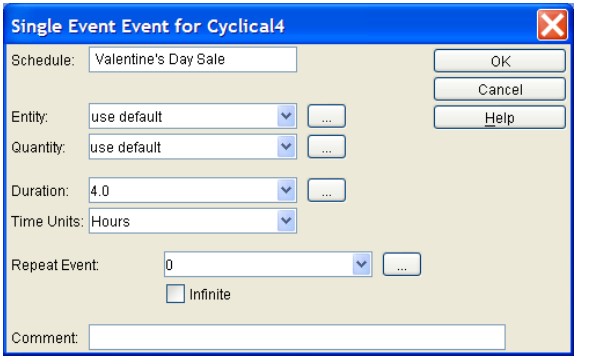
No Entities are generated by the calendrical event for January. Here is why:

1. On January 3rd of simulation time, SIMPROCESS acts on the calendrical cycle. It checks the **Date and Time** value (which is set to the 2nd of the month, at midnight) and compares it to the current date. SIMPROCESS determines that the trigger date has already passed and bypasses entity generation. The next possible trigger point is on February 2nd.
2. The calendar cycle continues until the end of the simulation or until the end of the active period for the Cyclical schedule.

Note that the Calendar event maintains control of the Cyclical schedule since there is no duration for the Calendar event.

Defining a Single Event Cycle

A Single Event cycle describes a one-time entity generation event:



A single event has the same parameters as a calendar cycle, except that when the event begins cannot be specified. A single event's starting date and time is dependent on the cycles that precede it in the pattern of cycles. Once the event is active, the generation occurs at the end of the duration.

Defining Inactive Time Periods

The **No Event** cycle defines a period of time during which no Entities are generated (for example, a holiday or weekend). The period of inActivity begins at whatever time SIMPROCESS invokes the **No Event** cycle.

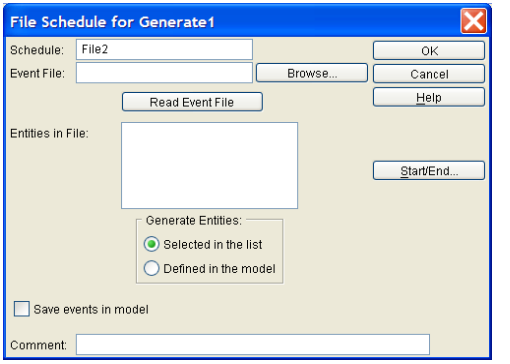
Defining Specific Entity Generation Events in a File

Entity generation events can be specified in an event file. An event file is created with a text editor or some other means independent of SIMPROCESS (such as a user written program). With an event file, a simulation can be run using data captured outside of SIMPROCESS.

For example, most mail order businesses use computer systems to track customer sales information. This information is stored in some kind of database. This information can be extracted from the database and a series of entity generation events defined that precisely matches customer activity for an actual day, week, month, etc. (Note that the database can also be read directly by SIMPROCESS. See "Interfacing With A Database" on page 296.)

Each record in an event file defines one entity generation event. To learn how to define entity generation events, see Appendix G–External Event Files, on page 577.

Use the **External File** schedule to identify an event input file to SIMPROCESS:



To identify the event file, click on the **Browse** button to the right of the **Event File** box. Use the resulting dialog to find and select the file.

The **Read Event File** button causes SIMPROCESS to read the event file, checking for syntax errors and building a list of the entity types and attributes referred to in the file. The **Read Event File** button must be clicked to complete the definition of the event file.

Refer to page 322 for a description of the **Start**/**End** option.

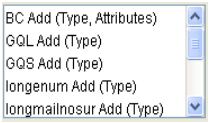
Identifying Entity Types to be Generated

An event file can contain records referring to many different entity types. An event record can even refer to a type of entity that has not yet been defined in the model and to entity instance attributes that have not been defined in the model. Which entity types SIMPROCESS should generate during

simulation can be specified precisely.

Select the **Generate Entities** option that indicates which of the entity types referenced in the event file are to be generated:

- **Defined in the model** tells SIMPROCESS to generate Entities for every event record that specifies an entity type already defined in the model.
- **Selected in the list** tells SIMPROCESS to generate Entities only for the types highlighted in the entity type list.



- If the event file refers to an entity type that is not defined in the model, it flags the type name. For example:

```
GQL Add(Type)
```

- Selecting this type will cause SIMPROCESS to add the entity type to the model.
- If the entity in the event file refers to entity instance attributes that have not been defined in the model, this is flagged as well. For example:

```
BC Add(Type, Attributes);
```

- Note that attributes are tied to Entities. Entity instance attributes cannot be added without adding the entity type.

To select the entity types to be used:

- Highlight the listed type name. To highlight several types, press and hold the **Ctrl** key while clicking on each item.
- To deselect a type, click on it again while pressing the **Ctrl** key.

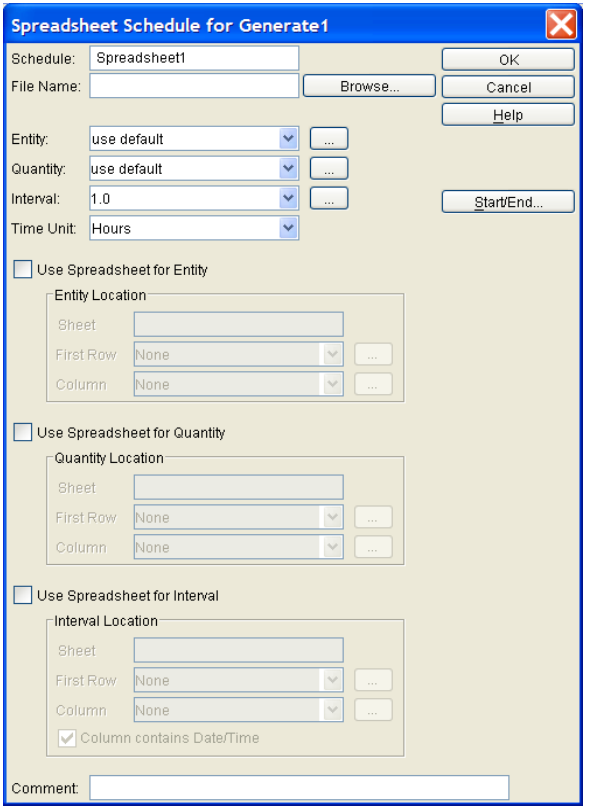
Saving Events

The option **Save events in model** determines whether the event file is needed for simulation. The option defaults to not selected. Not being selected means the event file will be read at simulation time. Thus, the file is required to run the simulation. If the option is selected, then the events are saved as a part of the model, and the file is not needed for simulation. However, saving events as a part of the model could significantly increase the size of the model file and increase the amount of time needed to load the model. If events are saved, the **Read Event File** button must be exercised if the event file changes. Otherwise, the simulation will not run with the events from the new file. Note that if the events are

not saved, and the event file changes, the events for the simulation will change. But, doing this without intentionally reading the event file using the **Read Event File** button assumes that the Entities and attributes used in the new file are the same as the previous file.

Adding a Spreadsheet Schedule

The Spreadsheet schedule allows full or partial generation events to be read from a spreadsheet.



The Spreadsheet schedule is essentially a Periodic schedule modified to allow spreadsheet entries to override the **Entity**, **Quantity**, and **Interval**. These fields operate as on a Periodic schedule unless overridden by the check boxes below.

The **File Name** field contains the name of the spreadsheet file. The spreadsheet can be a Workbook file or an XML Spreadsheet. If no path is included, the file is assumed to be in the model's directory. (It is recommended that the file be located in the model's directory. If the model and its directory are

moved, the **File Name** field will not need to be changed.) There are three options for overriding the defaults:

- **Use Spreadsheet for Entity**
- **Use Spreadsheet for Quantity**
- **Use Spreadsheet for Interval**

Selecting any option causes the **Sheet**, **First Row**, and **Column** fields for that option to activate. The **Use Spreadsheet for Interval** option also has a check box (**Column contains Date/Time**) that designates whether the column contains interarrival times or date and time information (default). All options assume the information is in a column starting at a particular row. No empty cells are allowed. For any option, if an empty cell is encountered in the designated column, the schedule stops operation.

Enter the appropriate Worksheet name in the **Sheet** field. **First Row** is the starting row for the events. The row number must be an INTEGER and must be greater than or equal to one. The **Column** field contains the column number of the data. As with the row number, the column number must be an INTEGER greater than or equal to 1. So if the data is in column A starting at row 1, **First Row** would be 1 and **Column** would be 1. Note that the **First Row** and **Column** fields contain the distribution list. Thus, evaluated values can be used as long as the above criteria are met.

Use Spreadsheet for Entity overrides the **Entity** field. Only Entity names defined in the model should be in the spreadsheet. If a value read does not correspond to an Entity defined in the model, a runtime error will occur. Entity names are case sensitive.

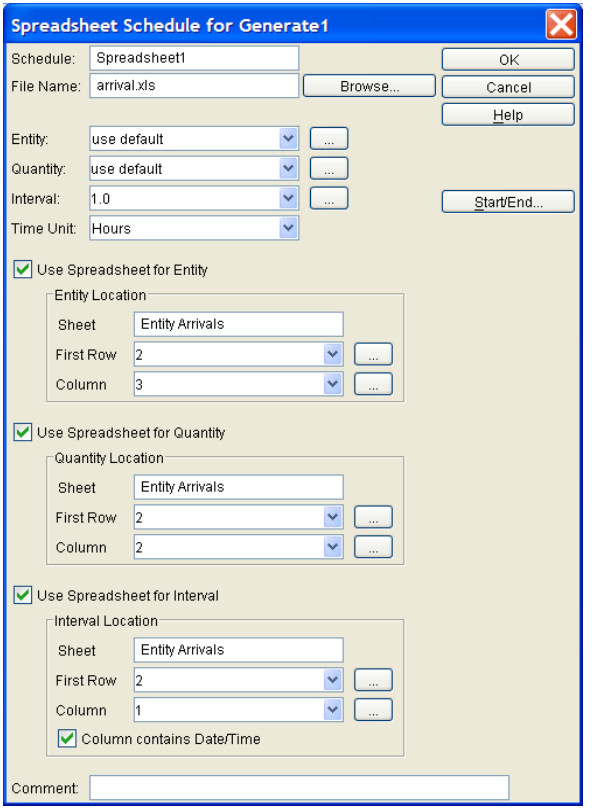
Use Spreadsheet for Quantity overrides the **Quantity** field. The values in the designated column should be numeric. If the value read is not an INTEGER, the value will be rounded to the nearest INTEGER.

Use Spreadsheet for Interval overrides the **Interval** field. If the values in the designated column are interarrival times, make sure **Column contains Date/Time** is not selected. Also, the **Time Unit** selected for the default **Interval** field applies to interarrival times read from a spreadsheet. If the values in the designated column are date and time values, the **Time Unit** field is ignored. Note that if the column contains date and time information, the column is assumed to be sorted in ascending order. An out of order date and time will cause the schedule to stop.

In the example below, `arrivals.xls` contains the complete generation event information since all three options are selected. All information is on the same Worksheet (Entity Arrivals), and all options start on the same row. In the spreadsheet excerpt below, the Generation Date contains no time information. This means the event will occur at midnight of the specified date. Time information must be included if generation at midnight is not acceptable (such as 1/4/2005 08:00:00).

Generation Date	Quantity	Entity
1/4/2005	30	Entity1
2/18/2005	3	Entity2
3/19/2005	16	Entity1
4/5/2005	15	Entity2
4/20/2005	2	Entity1
4/20/2005	11	Entity2

Note below that the values for each field (**Sheet**, **First Row**, and **Column**) can be different for each option. Typically **Column** will be different across options unless different Worksheets are used.



Refer to page 322 for a description of the **Start**/**End** option.

Adding an External Schedule

An external schedule allows a remote application to cause the generation of Entities within a SIMPROCESS model. This is a plug-in capability that can be purchased separately from CACI. Typical uses for external schedules include connecting decision support or operational systems to a SIMPROCESS simulation model to see how a model is affected by the randomness of real work applications in use rather than just randomness from statistical distribution functions. Other uses may include custom training software that allows students to interact with the simulation based on things they see occurring in the model – hence, influencing the remaining simulation.

An external schedule changes the normal operation of a simulation. If SIMPROCESS detects an external schedule within a model (and the appropriate license has been purchased), then the ending date and time specified in the **Run Settings** (page 109) is no longer active. Normally, if there are no more simulation events to process, then the end simulation event (which is based on the ending date and time specified in the **Run Settings**) is executed. When an external schedule is present and there are no more simulation events to process, the simulation suspends execution until an external schedule is signaled to generate Entities. Note that simulation time does not advance while simulation processing is suspended.

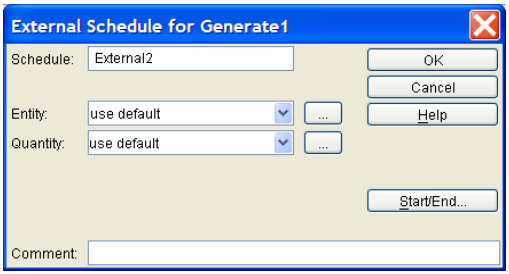
There are three ways to stop a simulation that contains an external schedule. The first is to manually stop the simulation using the Stop button, the F9 key, or **Simulate/Stop**. The second way is to route Entities to a Dispose Activity that has a maximum entity count set (page 80). When the maximum has been reached, the simulation will stop. The final way is to call the `stopSimulation` method of SPServerFactory (page 338).

Three actions must be accomplished before the start of the simulation in order to use an external schedule. The last two can be done before SIMPROCESS is started and can remain operational even though SIMPROCESS is closed and reopened.

- Create the external schedule in a Generate Activity
- Start the Java RMI Registry
- Start SPServer.

External Schedule Setup

Use the **External** schedule dialog to set the default **Entity** and **Quantity**.



The **Entity** and **Quantity** specified on the dialog can be overridden by the external application. Multiple external schedules can be specified in a single generate Activity or in different generate Activities.

Java RMI Registry

The Java RMI Registry must be started before SPServer or the simulation is started. This is because Java RMI is the protocol used to communicate between the external application and SPServer, and between SPServer and SIMPROCESS. The RMI Registry program (`rmiregistry`) is located in the Java Runtime Environment (JRE) included with SIMPROCESS. To start the RMI Registry locally, select **Tools/Remote/Start RMI Registry**. Note that once the RMI Registry has been started, it will remain active until SIMPROCESS is closed. Alternatively, a batch file or UNIX shell script can be constructed in the SIMPROCESS directory, because the RMI Registry program is required to have in its classpath the locations of files referenced by server processes. Here are some examples of what should be contained in those files:

In a Windows batch file:

```
set CLASSPATH=SPSYSTEM\simprocess.jar;SPSYSTEM\SPRemote.jar
rmiregistry
```

In a UNIX shell script using the Bourne shell or a derivative:

```
CLASSPATH=SPSYSTEM/simprocess.jar:SPSYSTEM/SPRemote.jar
export CLASSPATH
rmiregistry
```

In a UNIX shell script using the C shell or a derivative:

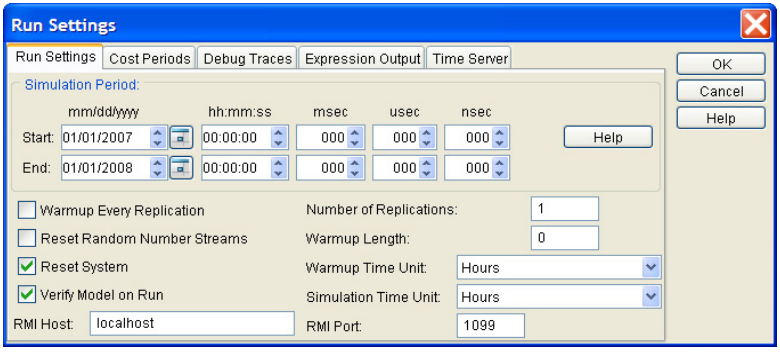
```
setenv CLASSPATH SPSYSTEM/simprocess.jar:SPSYSTEM/SPRemote.jar
rmiregistry
```

Sample batch files and scripts are located in the `SPUser\SampleFiles` directory. `SPUser` is located in the SIMPROCESS installation directory. The sample batch and script files are intended to be run from the SIMPROCESS installation directory.

SPServer

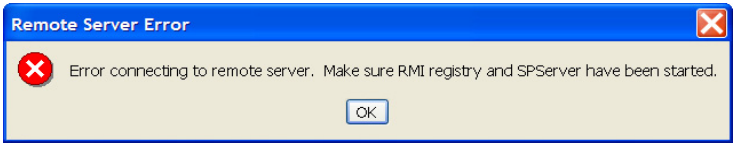
SPServer instantiates a single object called SPServerFactory. SPServerFactory creates instances of a server for each simulation that has an external schedule. SPServerFactory keeps track of which server instance is associated with which simulation. Thus, the user only needs to interface with SPServerFactory through a set of public methods. The user is responsible for creating the interface to SPServerFactory. If RMI Registry is running on the same system as SIMPROCESS, select **Tools/ Remote/Start SPServer** to start SPServer. To start SPServer from a command line in the directory in which SIMPROCESS was installed, type the command `jre/bin/java -classpath SPSYSTEM/simprocess.jar:SPSYSTEM/SPRemote.jar com.caci.remote.SPServer` (use backslashes and semicolons on Windows). Once the command has been executed, SPServerFactory is available through the Java RMI Registry using its bound name of "SPServer."

To run RMI Registry and SPServer on a host other than the host on which SIMPROCESS is running, and/or to specify a TCP port other than the default (1099), make the appropriate changes in the **Run Settings**. The sample files to start RMI Registry and SPServer can be copied from `SPUser\SampleFiles` to the appropriate system.



Running The Simulation

With the above steps complete, the simulation can be started. The simulation must be started before the external application attempts to communicate with SIMPROCESS. If not, an error will occur and the simulation will be terminated.



SPServerFactory API

When the simulation is running, the external or remote application can begin communicating with SIMPROCESS. In order to do this, the application must obtain a reference to SPServerFactory. However, since SPServerFactory is remote to the application, a "Stub" representation of SPServerFactory must be used instead. Stub classes are provided by RMI and serve as references to the methods of SPServerFactory that are available remotely. Because SPServerFactory was created according to RMI conventions, it implements a Java Interface containing the methods that may be invoked by the remote application. Therefore, the usual way to refer to it is by using the name of that Interface, SPServerFactoryInterface. That is, cast the item returned from the RMI Registry to the name of the Interface. The code fragment below is from an example remote application and shows the traditional way to refer to SPServerFactory.

```
import com.caci.remote.*;


import java.rmi.*;
import java.rmi.server.*;


public class ExternalApp {


public static void main(String args[]) {
    SPServerFactoryInterface spServer = null;
    boolean goodEvent = false;
    try {
     spServer =
      (SPServerFactoryInterface)Naming.lookup("rmi://localhost/SPServer");
    }
    catch (Exception e) {
        e.printStackTrace(System.out);
    }
```

The name `localhost` can be replaced with any valid entry that will resolve to the system on which SPServerFactory is running (including an actual Internet Protocol address). Note that the `Naming.lookup` method throws a `NotBoundException` and a `MalformedURLException` so this command must be within a `try` block.

The class com.caci.remote.SPServerFactoryInterface has these public methods for communication with SIMPROCESS models:

```
public double getSimTime(String modelName)
    throws RemoteException;


public boolean generateEntity(
    String modelName, String generate,
    String schedule, double time, int quantity)
          throws RemoteException;
public boolean stopSimulation(String modelName)
          throws RemoteException;
```

getSimTime returns a double representing the current simulation time. The time unit of this number is the simulation time unit specified in the **Run Settings**. Its single parameter, modelName, is the name of the simulation model (the same as its filename without the .spm extension).

generateEntity returns a boolean indicating success or failure. Its parameters are as follows:

- modelName is the name of the simulation model (the same as its filename without the .spm extension)
- generate is the name of the Generate Activity
- schedule is the name of the External schedule within the Generate Activity
- entity is the name of the Entity to create
- time is the simulation time at which the generation event should occur
- quantity is the number of Entities to generate for this generation event

The parameters entity and quantity can default to the **Entity** and **Quantity** specified on the external schedule dialog. A value of null or "" for entity will cause the default to be used. A value of 0 for quantity causes the default quantity to be used. The time parameter can default to the current simulation time by passing a value of -1.

stopSimulation returns a boolean indicating success or failure. modelName is the only parameter.

All methods throw a RemoteException.

External Application Example

The code below is a simple example of an external application communicating with SIMPROCESS. In this example, Remote is the name of the model (Remote.spm). The `for` loop runs from 1 to 10. For 1 and 2, the `generateEntity` method specifies all the parameters except `quantity`. The `generateEntity` method for 3, 4, and 5 specifies all the parameters. The `generateEntity` method for 6 through 10 only specifies the `model`, `generate`, and `schedule` parameters. The remaining parameters are set for defaults. The `generateEntity` method after the `for` loop calls the StopSim schedule. This schedule is set to generate a StopSim entity, which enters a Dispose Activity with a maximum entity count of 1, thus stopping the simulation. See Chapter 5 of the *SIMPROCESS Getting Started Manual* for instructions on running this example. The code (`ExternalApp.java`) is in the `SPUser\SampleFiles` directory. Also, in the `SPUser\SampleFiles` directory is `ExternalApp2.java`. This application is exactly the same as `ExternalApp.java`, but it uses `stopSimulation` to end the simulation.

```
package com.caci.demo;

import com.caci.remote.*;

import java.rmi.*;
import java.rmi.server.*;

public class ExternalApp {

public static void main(String args[]) {
    SPServerFactoryInterface spServer = null;
    boolean goodEvent = false;
    try {
     spServer =
      (SPServerFactoryInterface)Naming.lookup("rmi://localhost/SPServer");
    }
    catch (Exception e) {
        e.printStackTrace(System.out);
    }
    try {
        if (spServer != null) {
            for (int i = 1; i < 11; i++) {
                double time = spServer.getSimTime("Remote");
                time = time + 10.0;
                if (i < 3) {
                    goodEvent = spServer.generateEntity("Remote",
```

```
                        "Generate1", "External1", "Entity9", time, 0);
                }
                else if (i < 6) {
                    goodEvent = spServer.generateEntity("Remote",
                            "Generate1", "External1", "Entity6", time, 2);
                }
                else {
                    goodEvent = spServer.generateEntity("Remote",
                            "Generate1", "External1", null, -1, 0);
                } // end of inner if
                if (!goodEvent) {
                    System.out.println("Generate event failed");
                }
                try {
                    Thread.sleep(2000);
                }
                catch (Exception e) { }
            } // end of for loop
            goodEvent = spServer.generateEntity("Remote",
                    "Generate1", "StopSim", null, -1, 0);
        } // end of outer if
    } // end of try block
    catch (RemoteException re) {
        re.printStackTrace(System.out);
    }
} // end of main

} // end of ExternalApp
```

External Schedule Errors

If the call to `getSimTime` is not successful, a `-1` will be returned. If the call to `generateEntity` is not successful, `false` will be returned. Error messages from SPServerFactory or one of the server instances will be in the file `server.log` in the SIMPROCESS directory. If the error occurred within SIMPROCESS, the error messages will be in `simprocess.log` or `simprocess.err` in the SPSYSTEM directory.

Generate Activity Summary

The Generate Activity generates the Entities that are processed in a SIMPROCESS simulation:

The number of Entities generated at each generation event and the frequency of entity generation events may be expressed as either constant numbers or statistical distributions.

Schedules of discrete entity generation events can be defined. Schedules are classified as:

- *Periodic*: A constant or statistical distribution of generation events per time unit.
- *Calendar*: Daily, weekly, monthly, etc., events.
- *Weekly*: Schedule for a complete week.
- *Cyclical*: A detailed sequence of generation events.
- *File*: A schedule defined in an external file.
- *Spreadsheet*: A schedule defined in an external spreadsheet.
- *External*: A schedule that receives generation signals from an external application.

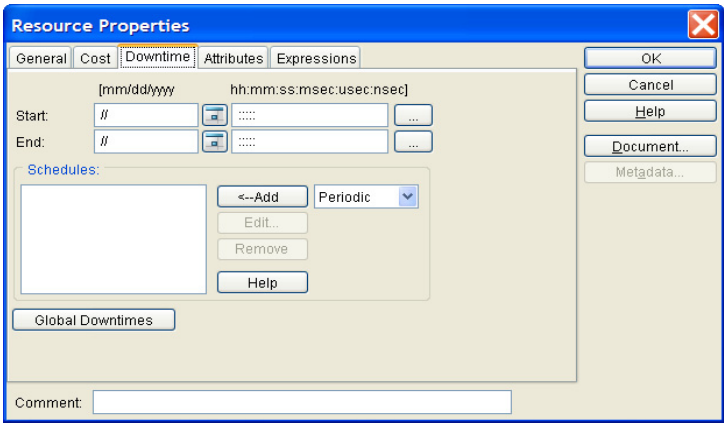
Cyclical schedules are further broken down into *cycles*, each of which describes a different entity generation event. Cycle events are processed sequentially. This differs from other Generate schedules, which are processed in parallel.

Resource Downtime

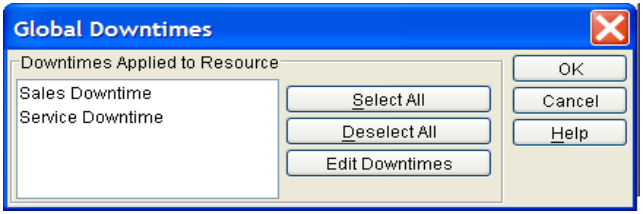
Resource Downtime determines when a resource is unavailable. Resource Downtime can be defined locally or globally. A Resource can have multiple global and one local Resource Downtime. Each global Resource Downtime for a particular Resource and the local Resource Downtime for the Resource operate independently. Thus, each can have different **Start** and **End** dates and times, and each can have different **Schedules**.

Local Resource Downtime

Local Resource Downtime is defined on the **Downtime** tab of the Resource properties dialog. Downtime defined on the **Downtime** tab of a Resource properties dialog will only apply to the Resource currently being edited.

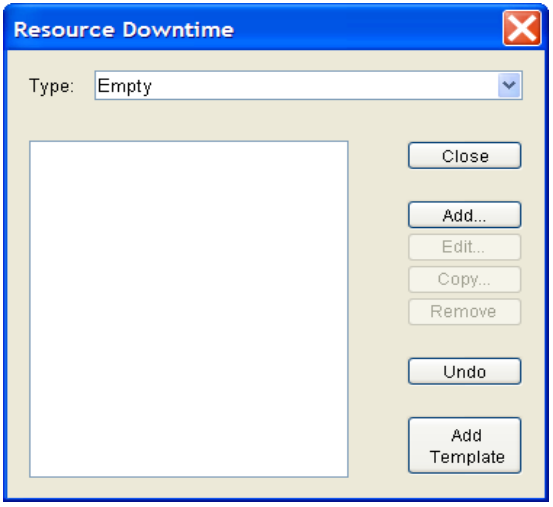


The global Resource Downtimes can be accessed while defining a local Resource Downtime. There is a **Global Downtimes** button on the **Downtime** tab of the Resource Properties dialog that displays a dialog that lists the global Resource Downtimes defined in the model. The global Resource Downtimes that are applied to the Resource are selected and can be modified. The global Resource Downtimes can be edited by selecting the **Edit Downtimes** button.



Global Resource Downtime

Global Resource Downtimes can be applied to any Resource in the model. They are defined by selecting the menu item **Define/Resource Downtimes...**.



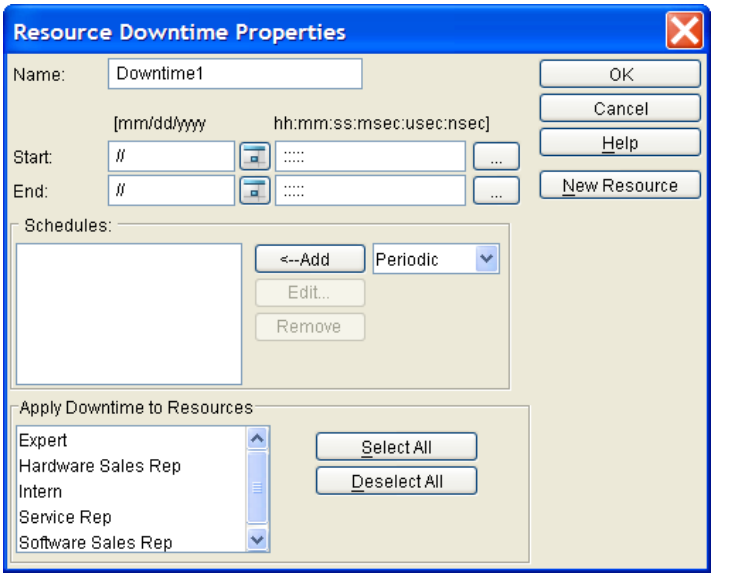
SIMPROCESS comes with three predefined Resource Downtime templates that are listed in the Type combo box on the Resource Downtime list dialog:

- Empty - Default Resource Downtime, with no Downtime scheduled.
- Night Shift - Includes a Downtime schedule that causes a Resource to only be available from 11 p.m. to 3 a.m. and from 4 a.m. to 8 a.m. Monday through Friday nights.
- Standard Shift - Includes a Downtime schedule that causes a Resource to only be available from 8 a.m. to noon and 1-5 p.m.

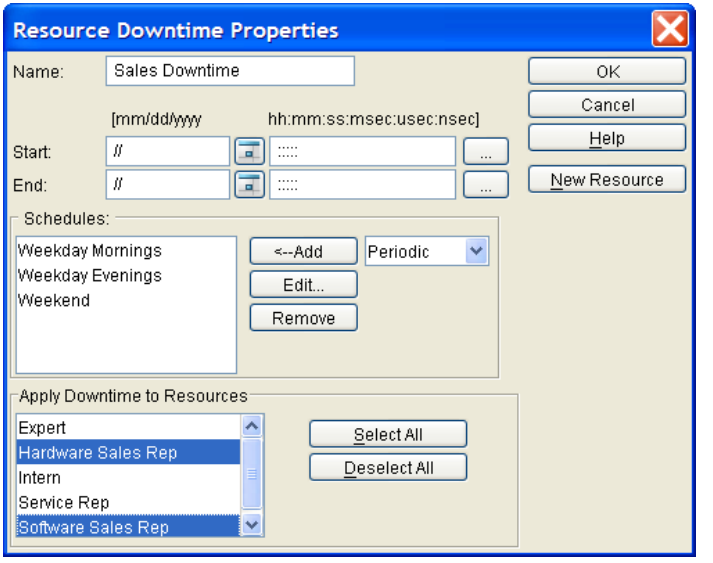
The **Add Template** button on the Resource Downtime list dialog creates a Resource Downtime template that can be saved in a Library. When the Library is loaded the Resource Downtime templates in the

Library are added to the **Type** list. See "Adding Resource Downtime Templates," beginning on page 232 for more information on creating Resource Downtime templates.

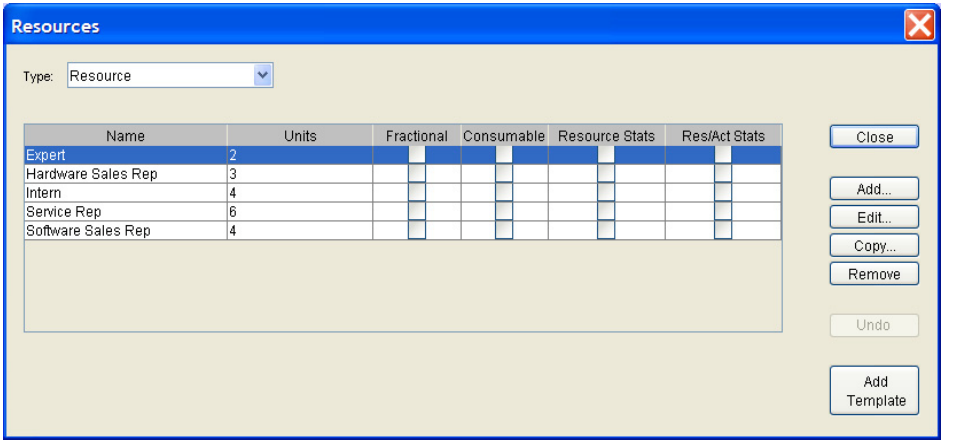
Selecting **Add** brings up a global Resource Downtime dialog.



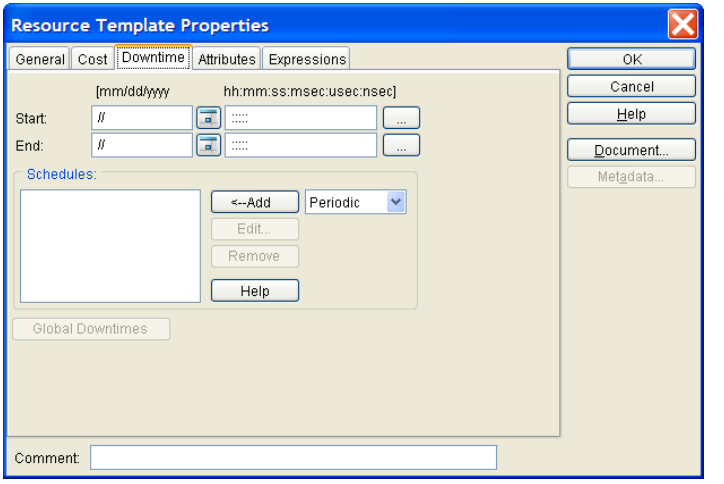
The Downtime's **Schedules** must be defined, and the Resources can be selected that will use this Downtime. Global Resource Downtime properties include a list of the Resources defined in the model. Apply the global Resource Downtime to Resources by selecting the appropriate Resources in the list. Control click to select multiple Resources or click **Select All** to select all the Resources.



Selecting the **New Resource** button displays the dialog that manages the Resources of the model.



Note that when a Resource is edited from the Resource Downtime Properties dialog, the **Global Downtimes** button on the **Downtime** tab is disabled. This is because the global Resource Downtime list is already open. Note that the **Global Downtimes** button will also be disabled when defining a Resource template.



Defining Downtime Schedules of Resources

Global and local Resource Downtimes have the same format. Both consist of **Start** and **End** dates and times and a list of **Schedules**. All schedules in the **Schedule** list are active only between the times specified in the **Start** and **End** fields. If no times are specified, they will default to the **Start** and **End** of the model. It is recommended, unless the modeling scenario requires specific dates, that the **Start** and **End** are left empty. If the **Start** and **End** of the model are changed, then the **Start** and **End** of resource downtimes are changed without having to re-enter the dates and times.

Dialog Field Definitions

- **Start** specifies the earliest time that the resource's downtime schedules are in effect. This field uses a *MM/DD/YY HH:MM:SS:MSS:USS:NSS* format. The millisecond, microsecond, and nanosecond portions may be left blank.
- **End** is the time beyond which the downtime schedules are not applicable. The same date/time format as **Start** is used. After this time, the resource will not go down.
- The **Schedules** list identifies the downtime periods defined for this resource. When a new downtime period is defined, it is added to this list.

Next to the **Add** button for the **Schedule** list box is a combo box containing the available downtime schedule types. There are three basic schedule types: **Periodic**, **Calendar**, and **Usage**. **Calendar** and **Usage** downtime schedules have variations.

A **Periodic** schedule of downtime is one that occurs at intervals of time. The interval may be fixed (every *n* time units) or random (sampled from a statistical distribution).

The **Calendar** schedules are calendar-based, with downtime occurring on particular dates or days of the week, time of day, etc. Types are:

Yearly - Every year, on a particular date and time.

Monthly - A specific day in each month (e.g., 1st of the month).

Weekly - A certain time of day, on the specified day of the week (e.g., Monday, Tuesday...)

Daily - Every day, beginning at the specified time.

Hourly - Every hour, beginning at *n* minutes past the hour.

Date - A specific date and time.

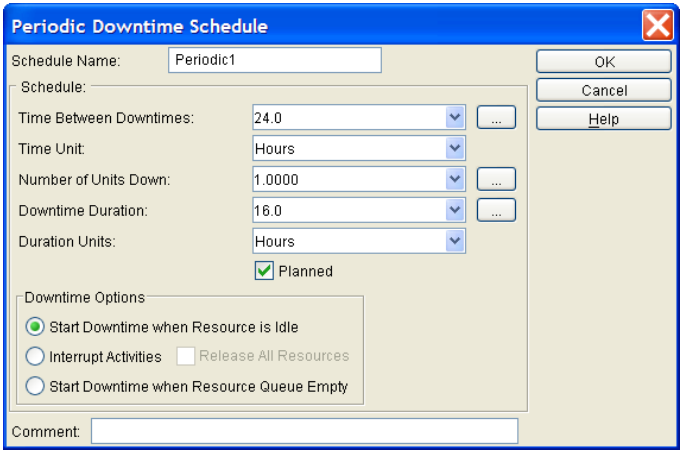
The **Weekly** schedule allows downtime to be defined for every day of the week.

There are two types of **Usage** downtime: **Unit Based** and **Time Based**. A **Unit-Based** schedule is based on the number of units of the resource that have been used. The amount of time the units were used is not considered. The **Time-Based** schedule considers the amount of time the resource has been busy.

When adding a new downtime schedule or editing an existing one, a dialog will display that contains the parameters for that downtime schedule type.

The **Downtime Schedule** dialog changes in appearance depending on the **Schedule Type** selected:

- If **Schedule Type** is periodic, the downtime occurs at intervals of time indicated in the **Time Between Downtimes** field. If the **Schedule Type** is calendar, the downtime occurs at the time specified.
- For **Time Between Downtimes** in a Periodic schedule, specify a statistical distribution or constant. For a Calendar schedule, specify a date and/or time.
- If **Schedule Type** is **Weekly**, a list of the days of the week appears. Select a day from this list.



- **Schedule Name** is the name assigned to the downtime period. This name appears in the **Downtime** list box.
- **Time Between Downtimes** defines the time at which the resource becomes unavailable.

  For **Periodic** schedules, this field is labeled **Time Between Downtimes** and contains either a statistical distribution or a constant. If a distribution is specified, the resource will be unavailable at random intervals based on the distribution sampling. If a constant is specified, the resource enters a period of Downtime every *n* time units. For example, to model a dayshift that works from 9 am to 5 pm and is off the rest of the day, specify 24 in this field and select Hours for the **Time Unit**. This means that every 24 hours (i.e., every day at 5 pm) the resource becomes unavailable.

  For **Usage** schedules, this field is labeled **Usage Before Downtime** and contains either a statistical distribution or a constant. Except for the first values, values from statistical distributions are obtained at the end of each downtime. If **Unit Based** is selected for **Usage Type**, **Time Unit** will be disabled. This is because time is not considered for **Unit-Based** downtime. However, units are considered for **Time-Based** downtime. For example, if two units of a resource are in use for the same one-hour period, then the amount of time the resource was in use is two hours (one hour for each unit).

  For all other schedules, this field is labeled **Date and Time** or **Time** and contains a date and/or time. Date is specified as a 2-digit month, 2-digit day, and 4-digit year. Time-of-day ranges from 0 to 2400 hours. Downtime of the resource begins at the time specified.
- **Number of Units Down** is the amount of capacity units to be made unavailable. This value can be variable. For instance, if all the capacity of the resource is to go down and an attribute was used for resource capacity, use that same attribute here. That way, when capacity changes,

the units down will change as well. Alternatively, using `Evl(Capacity)` for the **Number of Units Down** accomplishes the same thing. If the schedule is a global Downtime schedule that will be used with more than one Resource, always use `Evl(Capacity)` since the Resource capacity can vary from Resource to Resource. See "Evaluate (Evl) Function" on page 263 for a discussion of `Evl`, and see "System Attributes" on page 512 for a description of the Resource System Attribute `Capacity`. **IMPORTANT:** The **Number of Units Down** should not be larger than the number of units defined for the Resource.

- **Downtime Duration** is the length of time that the resource is unavailable. In the above daytime shift example 16 would be specified in this field. **Duration Units** is the time unit that applies to the **Downtime Duration**.
- **Planned** specifies that the period of unavailability is planned. For example, a vacation may be planned, whereas sick time is not planned. If unchecked, then the statistics for downtime display as Unplanned downtime.
- **Downtime Options** are used to set the rules for starting downtime (see below). **Downtime Options** are not available for **Usage** downtimes. This is because the downtime is based on usage. Therefore, the check for the start of downtime does not occur until the resource is released (**Start Downtime when Resource is Idle** option).
- **Start Downtime when Resource is Idle** is the default downtime option. This option specifies that Resource downtime will not start while the Resource is in use. As soon as a unit of the Resource has been released (and the downtime period has not passed), that unit is placed in a down state for the remaining period of the downtime. If the Resource is idle, then downtime starts immediately.
- **Interrupt Activities** signals SIMPROCESS to interrupt the processing of any Activities that are currently using this Resource. What happens to the Entities that are processing at an Activity that is interrupted is determined by the resource usage dialog of the Activity. (See "Adding Resource Requirements to Activities" on page 152.) If **Release Entities In Process at Start of Downtime** is not selected at the Activities, Entities using the resource at these Activities have their remaining processing time saved and are placed at the head of the wait queue for the resource. The entity does not leave the Activity and will remain there until all of its processing has completed. (Note that the Get Resource and Free Resource expressions for the Activities interrupted and the resource going down are not executed when the resource is released and re-obtained due to downtime.) When **Release Entities In Process at Start of Downtime** is selected, the entity is released; thus, any other resources obtained at the Activity are released. When an entity's processing is interrupted due to resource downtime, the entity instance expression **Interrupt Processing** for that entity is executed. When the entity re-obtains the resources so processing can continue, the entity's **Resume Processing** entity instance expression is executed. If the **Release Entities In Process at Start of Downtime** has been selected at the Activity, then the **Resume Processing** entity instance expression will not be executed since the entity leaves the Activity. If **Interrupt Activities** is not selected, the selected units of the resource will not go down until the resource has been released. **Interrupt Activities** also applies to Connectors with delays. Connectors cannot acquire Resources, but Entities

traversing a Connector can have Resources obtained at a Get Resource Activity. **Interrupt Activities** applies as described above for Get Resource Activities. If animation is on, Entities will pause on a Connector with a delay if a Resource carried by the Entity goes down due to **Interrupt Activities**.

- **Release All Resources** is only enabled if **Interrupt Activities** has been selected. This option only applies if more than one Resource is in use by an Entity when a Resource interrupts the processing of Activities at downtime. If **Release All Resources** is selected, when the Resource goes down, all Resources in use at that Activity are released. The Resource that is scheduled to go down is placed in a down state, and the other resources are available for another Entity to use. Note that this applies only to Resources assigned at the Activity that is interrupted. If a resource was obtained at another Activity, such as a Get Resource Activity, no Resources will be released. Those Resources will remain in a busy state during the time the Resource that is down remains down. Thus, **Release All Resources** only applies when all the Resources in use at an Activity were obtained at the Activity. If **Release All Resources** is not selected, none of the other Resources in use at the Activity will be released. They will remain in a busy state while the Resource that went down remains down. Note that the **Release Entities In Process at Start of Downtime** option on the Activity resource usage dialog overrides the **Release All Resources** option. If the **Release Entities In Process at Start of Downtime** option is selected, the Entity is released from the Activity at the start of the downtime, causing the release of all other Resources in use by the entity at that Activity.
- **Start Downtime when Resource Queue Empty** does not allow a Resource to go down until all Entities waiting for that resource have been serviced. For example, if there are three Entities waiting for a Resource because that Resource is busy, and downtime is scheduled to start, the Resource downtime will not begin until all three Entities have obtained the Resource and processed. Note that it is possible for a Resource to never go down if the time required to process the remaining Entities is greater than the **Downtime Duration**.

Note about Release All Resources

Care should be used when selecting this option. If more than one resource is being used at the Activity and one of these resources that has the **Interrupt Activities** option and **Release All Resources** option turned on goes down, several actions occur:

- All resources being used by the entity that were obtained at the Activity are released. This allows the resource going down to go down, and the remaining resources are available for another entity to use.
- The entity is placed at the head of the wait queue for each resource.
- When the resource is available again, the entity attempts to get all the needed resources. If all are available, the entity will continue processing with the remaining time. If the current Activity is the only Activity where the resources that did not go down are used, then all the resources should be reacquired immediately. If not, then it is possible that the resources that did not go down were obtained by an entity at another Activity and are not available. Thus, the entity must wait until the other resources are released.

Creating a Downtime Schedule

To demonstrate the creation of a downtime schedule, some of the periods during which a sales clerk is not available for work will be defined. Note that this is a local Resource Downtime schedule. If multiple resources followed the same downtime schedule, then the Resource Downtime should be defined globally. This downtime will account for:

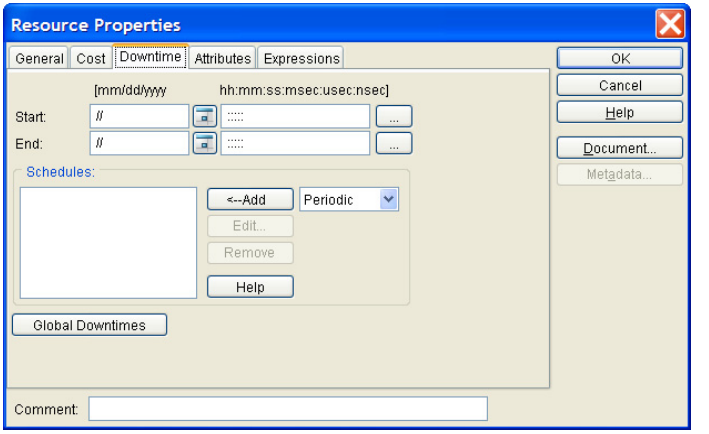
- Daily off-hours (the 16 hours of each 24-hour day that a person is not scheduled to work)
- Weekends
- Sick days.

A complete model would also need to account for lunch hours, vacation time, and unplanned time off (jury duty, personal days, acts of nature, etc.).

For this example, assume that sales clerks operate in two shifts. The first shift, composed of 3 clerks, works from 9 to 5. The second shift, consisting of 2 clerks, works from 2 to 10.

1. If the **Resource** dialog is not already displayed, click on the **Define** menu bar item, and then select **Resources...** Select *Clerks* from the list of resources, and then click on **Edit**.

   Click on **Downtime**.



2. If necessary, set the **Start** and **End** dates. The **Start** and **End** dates are used in conjunction with the **Start Date** and **End Date** of a simulation run (see "Run Settings" on page 88). Normally **Start** and **End** remain empty. When empty, the downtimes will apply to the whole simulation period. For example, if the simulation is scheduled to run for the year 2004, and the downtime should apply only to the month of January, then a **Start** of 1/1/2004 and an **End** of 2/1/2004 should be entered. Keep in mind that if the simulation run dates are entirely outside of the period defined for the downtime schedule, the downtime schedule will not apply to that simulation.

3. Define the daily hours during which Shift 1 workers *do not* work. Their weekday work shift is from 9 to 5, so they are unavailable from 5:00 p.m. to 9:00 a.m. the following day:

   Schedule Name can be anything. For this example it is *OffShift1*.

   For **Schedule Type**, select **Calendar** and then select **Add**.

   Select **Daily** for **Type**.

   For **Time** (the starting time of the downtime period), enter *17* under HH (1700 hours; 5 p.m.), and *0* under MM and SS. Milliseconds, Microseconds, and Nanoseconds may be left blank.

   In the **Number of Units Down** field, enter the number *3*. This is the number of clerks on Shift 1.

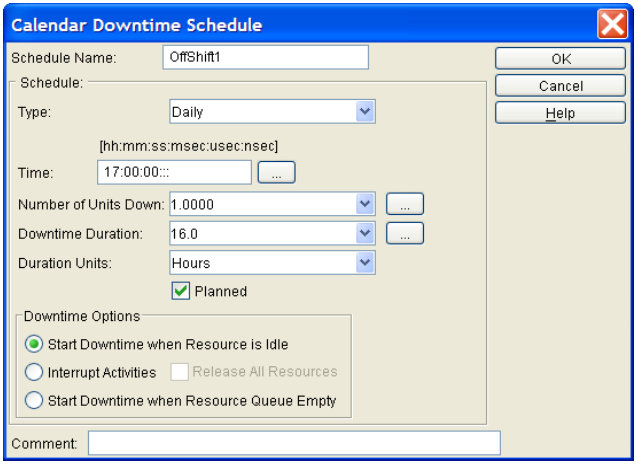
Remember that the resource **Units** of *Clerks* is 5, so 3 of the 5 will be unavailable during the period being identified.

Downtime Duration is *16.0*, the number of hours (since the **Duration Units** is set to **Hours**) between the end of one work day and the beginning of the next.

Unavailability occurs at regularly scheduled times, so select **Planned**.

Leave **Interrupt Activities** unselected since the clerks finish their current tasks before going down.

Click on **OK** when the definition is complete; *OffShift1* is added to the **Schedule** list.



4. Define the off-shift period for the two Shift 2 workers. Add another daily downtime schedule. Change **Time** to *22:00,* **Number of Units Down** to *2*, and name the schedule *OffShift2*. Then click on **OK**.
5. Define downtime periods to account for the weekend. Begin with Shift 1:

   For **Schedule Name**, call it *WeekendShift1*.

   Schedule Type is *Calendar*. The **Type** is *Weekly*. A weekend occurs once every week.

   When adding a **Weekly** schedule, a list box with the days of the week appears on the dialog.

   Day of Week is *Saturday*.

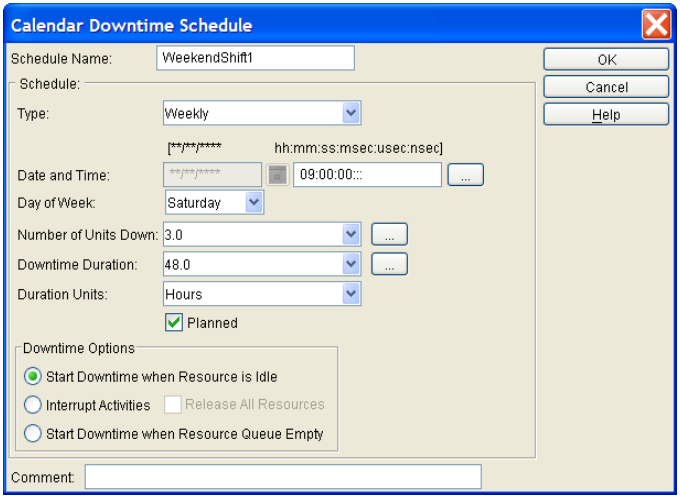
   For **Date and Time**, enter *9* under HH and *0* under MM and SS. Again, Milliseconds, Microseconds, and Nanoseconds may be left blank.

   If a typical weekend begins after work on Friday, remember that the time between 5 p.m. Friday and 9 a.m. Saturday was accounted for in the *OffShift1* period.

In the **Number of Units Down**, enter the number *3*. This is the number of clerks on Shift 1.

Downtime Duration is *48.0*.

Select the **Planned** check box.



Click on **OK** when finished.

6. **Add** the weekend Downtime period for Shift 2. Change **Downtime** to *14:00*, **Number of Units Down** to *2*, and name the schedule *WeekendShift2*.
7. Finally, time unavailable due to illness will be defined. Illness is more complex to model than weekends or overnights, because it occurs randomly. Random downtime is handled by specifying a frequency distribution instead of a fixed interval of time. Frequency distributions will be introduced here to complete the example.

Defining a Random Downtime

Illness is unplanned. Employees are going to get sick, but when it will happen, who it will happen to, or how long they will be out is unknown. However, reasonable estimates can be made based on past experience.

To define the **Downtime** schedule for sick days:

1. Add a **Periodic Schedule Type**.

   A Periodic schedule is used to describe events that occur at varying intervals of time.

2. **Time between Downtimes** describes the interval period.

   Assume that, in a typical month, one of the five employees comprising the *Clerks* group will be out sick for a period of time. Moreover, assume that while a month is typical, the time between bouts of illness can be as little as three days or as much as a year. To reflect this, specify a triangular distribution:

   Click on the arrow next to the **Time Between Downtimes** field to display a list of statistical distributions.

   Scroll through the list to the default definition for **Triangular** distributions. It reads:

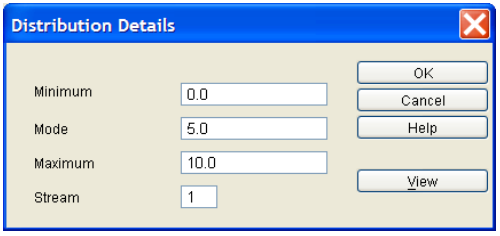
   ```
   Tri(0.0,5.0,10,0)
   ```

   There are three parameters in this definition: **Minimum** value, most frequent value (**Mode**), and **Maximum** value. Values are in the **Time Unit** selected.

   Select **Tri...** from the list.

   Click on the box to the right of the arrowhead next to the **Time Between Downtimes** field.

   This displays a dialog for defining the parameters of the distribution:

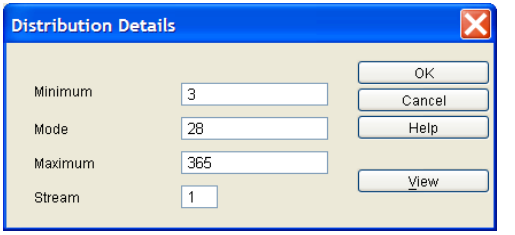


   The following assumptions have been made:

   Typically, there is a clerk out sick every 28 days. This is the most likely estimate.

   The minimum period between illnesses is 3 days.

   The maximum period between illnesses is 1 year (365 days).



Click on **OK**.

3. Set **Time Unit** to *Days*.
4. Set **Units Down** to *1*.

   The **Units** (number of clerks) of this resource is 5. The frequency of downtime applies to one clerk at a time, not all five.

5. **Downtime Duration** is another variable, random event.

   For this model, assume that a clerk is unavailable for at least 24 hours (one sick day), and no more than 10 days at a time, with most absences lasting two days. Following the procedure described in step 2, define a triangular distribution with these parameters:

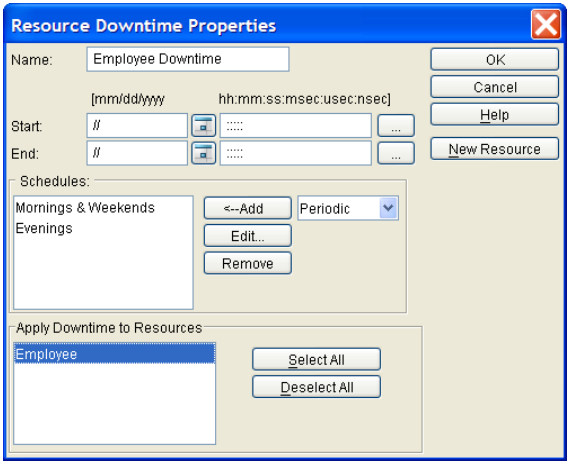
6. Select *Days* for **Duration Unit**.
7. Set the **Schedule Name** to *SickTime*.
8. The downtime is not planned, so leave the **Planned** check box blank.
9. Leave **Interrupt Activities** unselected.
10. Click on **OK** to add the definition to the **Schedule** list.

Click on **OK** to accept the entire **Downtime Schedule**.

Defining a Weekly Downtime

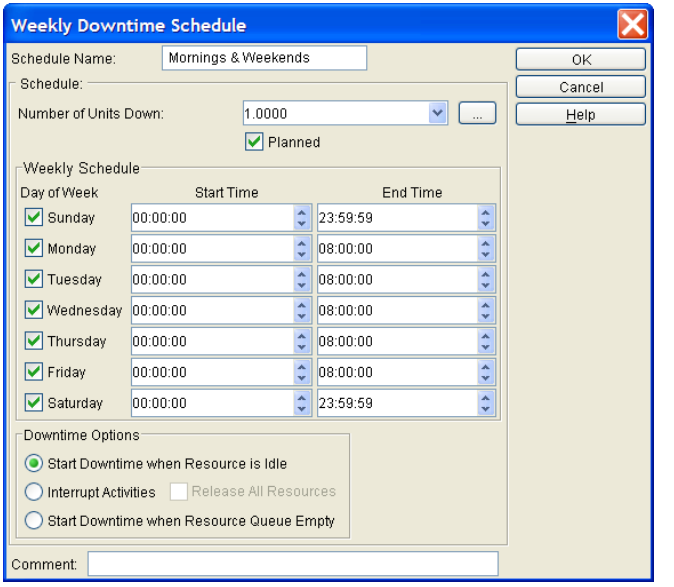
The Weekly Downtime schedule is good for resources where availability is based on a schedule. An employee work schedule is a good example. The Weekly Schedule can be use to schedule the unavailability of the employee. Consider a Resource that represents an employee that works 0800 to

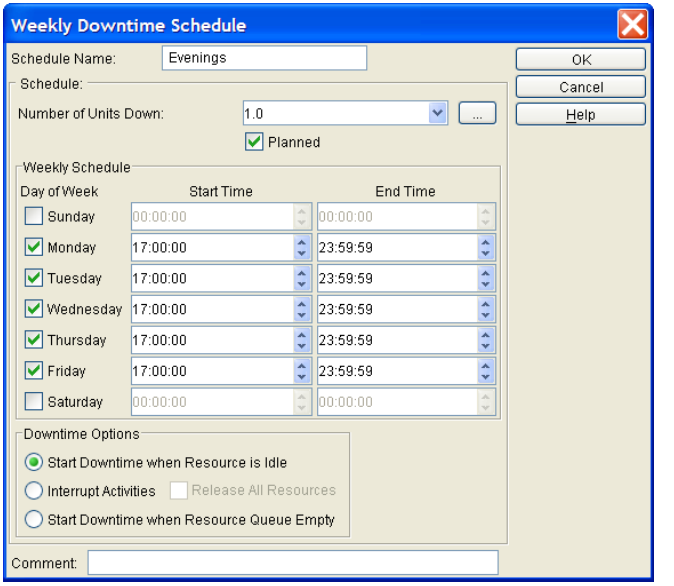
1700 Monday through Friday. Thus, the employee resource would be unavailable on weekends and mornings and evening of weekdays. Two Weekly schedules would set the appropriate downtime. Below is a Global Resource Downtime that shows two Weekly schedules.



The first schedule, Mornings & Weekends, contains the downtime for each weekday morning and the weekend. Each **Day of Week** is selected in this schedule. The second schedule, Evenings, contains the downtime for each weekday evening. Only the weekdays are selected for this schedule. Note that **Saturday** and **Sunday** on the Mornings & Weekends schedule, and each weekday on the Evenings schedule has 23:59:59 as the **End Time**. When 23:59:59 is encountered in the **End Time** field, the last second is added so the downtime continues to midnight of the following day. If both **Start Time** and **End Time** contain 00:00:00, then a full 24 hour day is assumed.

See "Defining Downtime Schedules of Resources" on page 347 for information on **Number of Units Down**, **Planned**, and **Downtime Options**.


Weekly Downtime Schedule
Schedule Name: Mornings & Weekends
OK
Cancel
Help
Schedule:
Number of Units Down: 1.0000
...
Planned
Weekly Schedule
Day of Week
Start Time
End Time
Sunday 00:00:00 23:59:59
Monday 00:00:00 08:00:00
Tuesday 00:00:00 08:00:00
Wednesday 00:00:00 08:00:00
Thursday 00:00:00 08:00:00
Friday 00:00:00 08:00:00
Saturday 00:00:00 23:59:59
Downtime Options
Start Downtime when Resource is Idle
Interrupt Activities
Release All Resources
Start Downtime when Resource Queue Empty
Comment:

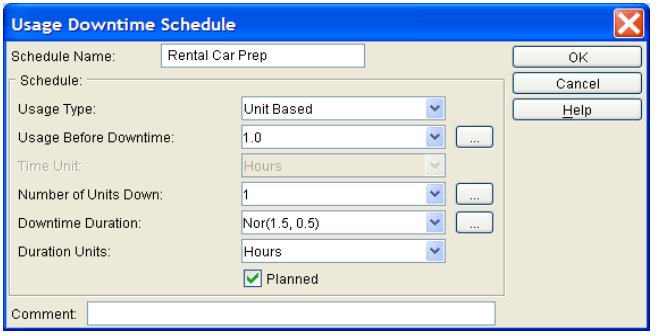

Weekly Downtime Schedule
Schedule Name: Evenings
OK
Cancel
Help
Schedule:
Number of Units Down: 1.0
...
Planned
Weekly Schedule
Day of Week
Start Time
End Time
Sunday 00:00:00 00:00:00
Monday 17:00:00 23:59:59
Tuesday 17:00:00 23:59:59
Wednesday 17:00:00 23:59:59
Thursday 17:00:00 23:59:59
Friday 17:00:00 23:59:59
Saturday 00:00:00 00:00:00
Downtime Options
Start Downtime when Resource is Idle
Interrupt Activities
Release All Resources
Start Downtime when Resource Queue Empty
Comment:

Defining a Usage Downtime

Sometimes a resource should be unavailable after use. As an example, consider the scenario where the resource is a rental car. When the rental car is released after use, the resource must be unavailable for some time to represent the time required to clean, maintain, and refuel the car. A **Unit Based Usage** downtime schedule can model this scenario.

To define the **Downtime** schedule for rental car usage:

1. Add a **Usage Schedule Type**.
2. Select **Unit Based** for **Usage Type**.
3. **Usage Before Downtime** sets the number of units that must be used before downtime occurs. The arrow next to the **Usage Before Downtimes** field displays a list of statistical distributions. No change is needed since the default of 1.0 is correct. This means every unit of the rental car resource will go down for a period of time when released.
4. Set **Number of Units Down** to 1.0.
5. Select the Normal distribution (`Nor`) for **Downtime Duration**. The **Downtime Duration** represents the time required to prepare the rental car for another use. Enter 1.5 for the Mean and 0.5 for the Std Dev.
6. Leave the **Duration Units** at the default value (Hours).



Modifying a Downtime Schedule

Removing existing **Schedule** items from a **Downtime Schedule** is simple: open the global or local **Downtime Schedule**, highlight the **Schedule** item to delete, and click on **Remove**.

To change a **Schedule** item, select it from the **Schedule** list, click on **Edit,** and then modify the parameters on the **Downtime Schedule** dialog. Click on **OK** to accept the changes.

The **Add** button updates the **Schedule** list box to include the schedule just defined.

The **OK** button finalizes the changes made to the **Downtime Schedule**.

The **Cancel** button exits the **Downtime Schedule** dialog without accepting any schedule changes made.

Event Logs

Time Stamps and Recorders are event logs supported in SIMPROCESS.

Time Stamping is a facility that SIMPROCESS offers for monitoring times between any two events. For example, start to finish time. The three steps for using Time Stamps are:

- Defining Time Stamps
- Adding Entry/Exit Event Logs to Processes/Activities
- Viewing Time Stamp Reports

Defining Time Stamps

A Time Stamp can be thought of as a label or key that contains the current simulation time. This key is added to an entity by an Event Log when it either enters or leaves a Process or Activity. Pairs of keys can be specified and Entity cycle times can be computed between them.

Time Stamping can be performed upon entry (and/or) exit from an Activity. Time Stamp specifications can be defined between two stamp keys, enabling the monitoring of cycle time & counts between two Time Stamps.

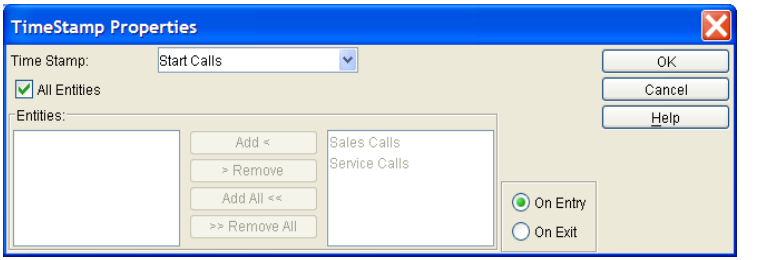
1. Select **Time Stamps...** from the **Define** pull-down menu.
2. Select **Add** to define **Time Stamp** requirements.
3. Define **Start** and **Stop** keys, select the whether or not to **Collect Statistics** (results available in Standard Report), and select plot options (**Real-Time Trace Plot**, **Real-Time Histogram Plot**).
4. The **Set Plot Properties** button brings up a plot properties dialog for each plot selected. See “Setting Plot Properties” on page 202.
5. Define as many **Start** and **End** keys as desired. Press the **Close** button when finished.

Entry and Exit Event Logs to Processes/Activities

Once **Time Stamp**s have been defined, specify the Process or Activity where they will be attached to the Entity. The **Time Stamp** can be added to the Entity upon entry into and/or exit from the Process/Activity. Time stamps are then added to Entities that traverse this process during simulation execution. To add a time stamp:

1. A **Time Stamp** must first be defined using the procedures starting on page 362.
2. Using an **Activities/Process Properties** dialog, select the **Event Logs** tab.

3. Using the **Type** combo box, select **Time Stamp** and press the **Add** button. The **Time Stamp Properties** dialog appears, as shown below.



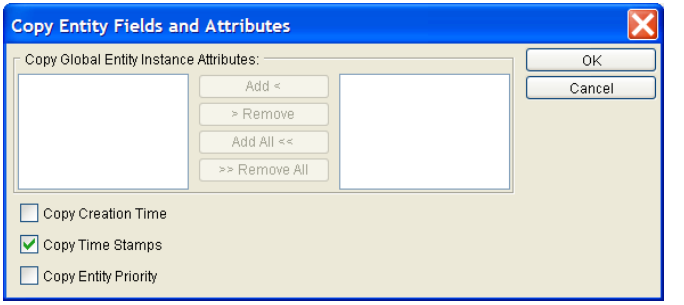
4. Select either one or more individual Entities by using the **Add<** button. Check the **All Entities** box to stamp every entity in the model.
5. Choose either the **On Entry** or **On Exit** check boxes for the **Time Stamp**.
6. Select a **Time Stamp Key** in the combo box which contains the predefined time stamp labels.
7. Press the **OK** command button and notice the **Time Stamp** report name in the **Event Logs** list box.

Passing Time Stamps Between Entities

When an entity enters a Clone, Split, or Transform Activity, a new instance of an entity type leaves that Activity. The Original entity, when it leaves a Clone or Split Activity, will continue to carry Time Stamps that were defined upstream on the entity. The Clone Entities will not, by default, carry those Time Stamps defined on the Original entity. Clone Entities can also inherit the Time Stamps of the Original entity.

On the **Properties** dialog of the Clone Activity, simply click on the **Copy Time Stamps** check box. This will cause each instance of the Clone Entities to carry the Time Stamp information inherited from the Original entity.

To specify that the Clone Entities resulting from a Split Activity inherit Time Stamp information from the Original entity, edit the **Properties** of the connector(s) emanating from the Clone pad. Now, click on the **Copy Attributes** button. This will open the **Copy Entity Fields and Attributes** dialog. This dialog contains the same **Copy Time Stamps** check box described above.



The **Properties** dialog of the Transform Activity has a **Copy Attributes** tab that works the same as the dialog from the **Copy Attributes** button on the Split connector.

When an entity carrying a Time Stamp is Batched or Assembled, the output entity will not be aware of the Time Stamp. The output entity must be unbatched in order to register the endpoint of the Time Stamp (to do this for an Assembled entity, turn on the **Batch Component Entities** check box on the **Properties** dialog of the Assemble Activity).

Differences Between Time Stamps and Recorder Objects

Time Stamps measure time delays during a simulation. How much time an entity spends at one or more Processes/Activities is captured using Time Stamp keys.

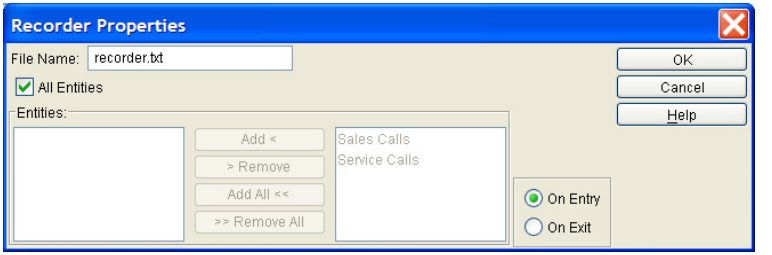
Recorder Objects measure arrival/departure rates at Processes/Activities by recording how many Entities arrive/depart a Process/Activity over time. The time between arrivals and departures can also be calculated using Recorders.

Recorders

In addition to Time Stamps, Recorders will write the arrival or departure time of an entity at a Process/Activity into a file called `recorder.txt`. The file can be examined after the simulation to observe the actual times a specific Entity arrived or departed from specific Processes/Activities.

1. Using an **Activities/Process Properties** dialog, press the **Event Logs** tab. The **Event Logs** tab lists the currently defined **Time Stamp**s and **Recorder** objects (either **On Entry** or **On Exit**).

2. Using the **Type** combo box, select **Recorder** and choose the **Add** button. The **Recorder Properties** dialog appears, as shown below.



3. Choose to record arrival times (**On Entry**) or departing times (**On Exit**) of the **Entities** in this Process/Activity.
4. Select the Entities to record. If the **All Entities** check box above the list box is selected, all Entities in the list box will be recorded
5. Choose **OK** to leave the dialog when finished entering data, confirming the current selections. The **Cancel** button rejects the current dialog selections.
6. The **Event Logs** tab shows the defined **Recorders** (either **On Entry** or **On Exit**) along with current **Time Stamps**.

Part C
Advanced SIMPROCESS Tools

The chapters in this section describe the advanced tools and the database included with SIMPROCESS Professional.

CHAPTER 12

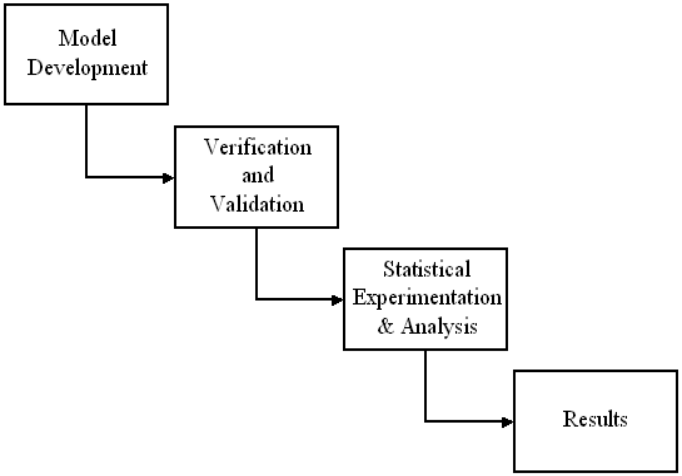
Advanced Data Analysis

SIMPROCESS comes with two data analysis tools that extend the ability to conduct statistical data analysis: ModelFit and ExpertFit.

ModelFit provides automated fitting of distributions from sample data. It is used with the SIMPROCESS Auto Fits feature (see "Auto Fits Distributions," beginning on page 101).

The ExpertFit tool:

- Increases the accuracy of experiments
- Decreases the time to find the solution to the problem
- Provides a statistical software tool tailored to the statistical simulation environment
- Provides a unique graphical user interface
- Performs data analysis
- Models random processes



ExpertFit is used to analyze data and construct a data model of the random process that generated the data. An introduction to the statistical background for data analysis and data modeling is provided in the following section, “An Introduction to Data Analysis and Modeling.”

An Introduction to Data Analysis and Modeling

Introduction

Probability distributions are a way of describing the random variations that occur in the real world. Although the variations are called random, there are different degrees of randomness, and the different distributions correspond to how the variations occur. Consequently, different distributions are used for different purposes.

Probability distributions are represented by probability density functions. Probability density functions show how likely a certain value is. The more likely the value, the larger the probability density function at that point. The total probability at all points should sum to 100%, so the area under a probability density function is equal to one.

Cumulative density functions give the probability of selecting a number at or below that value. For example, if the cumulative density function value at 1.7 was equal to .75, then 75% of the time, selecting from that distribution would give a number less than 1.7. The value of a cumulative density function at a point is the area under the corresponding probability density curve to the left of that value. Since the total area under the probability density function curve is equal to one, a move towards more positive values in a cumulative density function approaches one.

Knowledge of all these details is not needed to effectively model a situation. Knowing which distribution best fits the data is most important. The curve fitting capabilities of ModelFit and ExpertFit make it easy to find the correct distribution for data.

In addition, standard distributions can be examined visually for different combinations of input parameters.

Standard Statistical Indicators

There are several statistical indicators that can tell a lot about the distribution of random values. Consult an introductory statistics textbook for detailed discussions of these indicators. This section simply gives their meanings and some of their implications. More definitions can be found in the "Statistical Tools Glossary," beginning on page 505 at the end of this manual.

The mean is the most important characteristic of a data sample. Always try to get a good value for the mean (from actual data, if possible) if the scenario represents a time to complete some task or the number of arrivals in a certain time period.

The mode is the most likely value in a set of data. Consider the following list of numbers:

2, 3, 3, 3, 9, 10

The mode for this set of data is 3, since it occurs most frequently. The mean for this set of data is 5. If a distribution is symmetric about the mean, and singly-peaked, then the mode and the mean will be equal. In this case, the distribution contains a couple of large values which shift the mean away from the mode.

As discussed later, the mode is an important parameter for specifying a triangular distribution.

The standard deviation is a simple measure of the spread in the data. It is calculated by finding the mean, summing the squares of all the differences between the mean and the data points, taking the square root of this value, and then dividing by the square root of the number of data points. Loosely, it is the average difference from the mean. Why are the square and square root are taken? Because the result would be zero if just the differences were summed!

The standard deviation is a measure of how much spread there is in the data. If the standard deviation is large, there is a wide variation in the data. If it is small, the data are tightly clustered around the mean. The standard deviation is a necessary piece of information for many standard distributions. The variance is the standard deviation squared.

Most of the parameters for continuous distributions can be classified, on the basis of their physical or geometric interpretation, as being one of three basic types: location, scale, or shape parameters. The following discussion is taken from the book *Simulation Modeling and Analysis* (Third Edition) by Law and Kelton (2000).

> A location parameter l specifies an abscissa (x axis) location point of a distribution's range of values; usually, l is the midpoint (e.g., the mean of a normal distribution) or lower endpoint (e.g., location for a Pearson type V distribution) of the distribution's range. As l changes, the associated distribution merely shifts left or right without otherwise changing. Also, if the distribution of the random variable X has a location parameter of 0, then the distribution of the random variable $Y = X + l$ has a location parameter of l.
>
> A scale parameter b determines the scale (or unit) of measurement of the values in the range of the distribution. (The standard deviation is a scale parameter for the normal distribution.) A change in b compresses or expands the associated distribution without altering its basic form. Also, if the random variable X has a scale parameter of 1, the distribution of the random variable $Y = bX$ has a scale parameter of b.
>
> A shape parameter a determines, distinct from location and scale, the basic form or shape of a distribution with the general family of distributions of interest. A change in a generally alters a distribution's properties (e.g., skewness) more fundamentally than a change in location or scale. Some distributions (e.g., exponential and normal) do not have a shape parameter, while others (e.g., beta and Pearson type VI) may have two.

A probability density function is a representation of a statistical distribution. The probability density

function is large for likely values sampled from a distribution and is small for unlikely values. The maximum value for the probability density function is equal to the mode for that distribution. The area under the probability density function curve within a certain range of values gives the probability of sampling from that distribution and getting a number within that range. Of course, the total area under the curve must be equal to one, since a number from the distribution must be less than or equal to one.

A confidence interval is the range of values a certain percentage of the population would be expected to fall into if the sample were drawn from a normal distribution. Plus or minus one standard deviation corresponds to about a 68% confidence interval; plus or minus two standard deviations corresponds to about a 95% confidence interval; and plus or minus three standard deviations corresponds to about a 99.7% confidence interval.

Why Statistical Simulation Experiments?

Mean-Value Analysis

Mean-value analysis is a simple, although often quite useful, approach to modeling. The basic philosophy is to model processes by their average output.

For example, suppose there is a station that can process five parts per hour, and on average four parts arrive every hour. Mean-value analysis shows that the station should be able to handle the expected load.

However, in the real world there might be some hours the station may process only three parts, and other hours it may process seven. Likewise, there may not be a perfectly steady flow of four parts into the station every hour. Sometimes there may be more and sometimes less.

This statistical nature of the real world will lead to a diminished throughput, for there will be times when the station is idle, and other times when it is backed up, disrupting the flow to and from it in the rest of the factory. This is the limitation of mean-value analysis, and the reason that simulation is necessary for accurate predictions.

The Importance of Experimental Data

It is very important to have experimental data as the basis of a model. This may seem like a paradox: If I am modeling something that does not exist, where will I get the experimental data?

This is not as big a problem as it sounds. The individual components of a similar existing system will probably be close enough to ones in the proposed system to be useful in the model. The data do not have to be exhaustive, *any data is much better than no data*.

In fact, a good test of the model building process is to build a model of an existing system and check how closely the model and the system match up. This can often be a key to convincing others of the validity of the simulation modeling approach.

SIMPROCESS Statistical Distributions

The following table contains the statistical distributions available in SIMPROCESS. Other distributions can be created from these using the Define Distributions function. See "Statistical Distributions" on page 477 for descriptions of each distribution.

Beta Distribution	**Bet(shape1, shape2, minimum, maximum, stream)**
Binomial Distribution	**Bin(trials, probability, stream)**
Erlang Distribution	**Erl(mean, shape, stream)**
Exponential Distribution	**Exp(mean, stream)**
Gamma Distribution	**Gam(mean, shape, stream)**
Geometric Distribution	**Geo(probability, stream)**
Hyper Exponential Distribution	**Hex(mean1, mean2, probability1, stream)**
Inverse Gaussian Distribution	**InG(location, scale, shape, stream)**
Inverted Weibull Distribution	**InW(location, scale, shape, stream)**
Uniform Integer Distribution	**Int(minimum, maximum, stream)**
Johnson S_B Distribution	**JSB(minimum, maximum, shape1, shape2, stream)**
Johnson S_U Distribution	**JSU(location, scale, shape1, shape2, stream)**
Log-Logistic Distribution	**LLg(location, scale, shape, stream)**
Log-Laplace Distribution	**LLp(location, scale, shape, stream)**
Lognormal Distribution	**Log(mean, standard deviation, stream)**
Negative Binomial Distribution	**NgB(s, probability, stream)**
Normal Distribution (non-negative)	**Nor(mean, standard deviation, stream)**
Normal Distribution (unbounded)	**Nrm(mean, standard deviation, stream)**
Pareto Distribution	**Par(location, shape, stream)**
Poisson Distribution	**Poi(mean, stream)**

Pearson Type V Distribution	**PT5(location, scale, shape, stream)**
Pearson Type VI Distribution	**PT6(location, scale, shape1, shape2, stream)**
Random Walk Distribution	**RnW(location, scale, shape, stream)**
Triangular Distribution	**Tri(minimum, mode, maximum)**
Uniform Distribution	**Uni(minimum, maximum, stream)**
Weibull Distribution	**Wei(shape, scale, stream)**

CHAPTER 13

SIMPROCESS Database

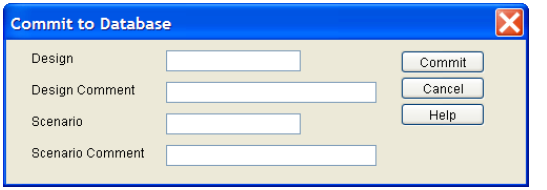
The Windows version of SIMPROCESS includes a Microsoft Access 2000 database (SimProcDB.mdb) designed to hold simulation results from simulation runs. This database includes predefined queries, graphs (forms), and reports, each of which can be modified to tailor the database for output analysis. The procedures for connecting the database to SIMPROCESS using ODBC are explained in the Getting Started Manual. (An Access 97 database is available upon request.)

SIMPROCESS can use other non-Access SQL databases by making appropriate entries in the `sProcDB.properties` file provided by the installer. This file is installed on both Windows and non-Windows systems and is pre configured for use with the Access database described above. Additional information is included in this chapter to aid in using a non-Access SQL database patterned after the Access database (SimProcDB.mdb) to hold simulation results.

Note that the discussion in this chapter is only concerned with storing simulation results in SimProcDB.mdb or in a user-created SQL database patterned after SimProcDB.mdb. There are expression statements that allow SIMPROCESS to read from or write to any SQL database. See "Interfacing With A Database" on page 296 for more information.

Committing Results to the Database

To commit simulation results to the database, select **Commit to Database** from the **Report** menu. The menu item will not be enabled until a simulation run is complete (either terminating normally or user terminated). If the database is not found, an error dialog will appear. If this occurs, recheck the database connection through the ODBC control panel if using the Access database, or recheck the values in the `sProcDB.properties` file. Normally, the **Commit To Database** dialog will appear. A design name and scenario name must be entered. The design and scenario comments are optional. What constitutes a design will be discussed in the next section.



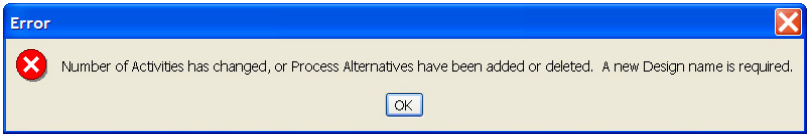
Once the information has been entered, click on **Commit**. At this point SIMPROCESS verifies that the design name and scenario name are allowable. If so, the results are stored in the database. When finished, the status bar shows **Commit Complete**.

System, Design, and Scenario

Three tables in the database control the results placed there: **System**, **Design**, and **Scenario**. The **System** table is the highest level table and contains the model name. Therefore, the database is designed to hold results from more than one model. If a record is deleted from the **System** table, all records related to that model are deleted from the Access database. (In order for this to be true in another SQL database, the appropriate relationships and/or constraints must be established when the database is created.) The **Design** table holds data from different versions of the same model. A model design consists of the following:

- Number of entity types
- Entity type names
- Number of resources
- Resource names
- Resource costs
- Number of Activities, Processes, and Process alternatives
- Names of Activities, Processes, and Process alternatives
- Activity/Process structure
- Start and End date
- Start and End time
- Number of replications
- Output time units.

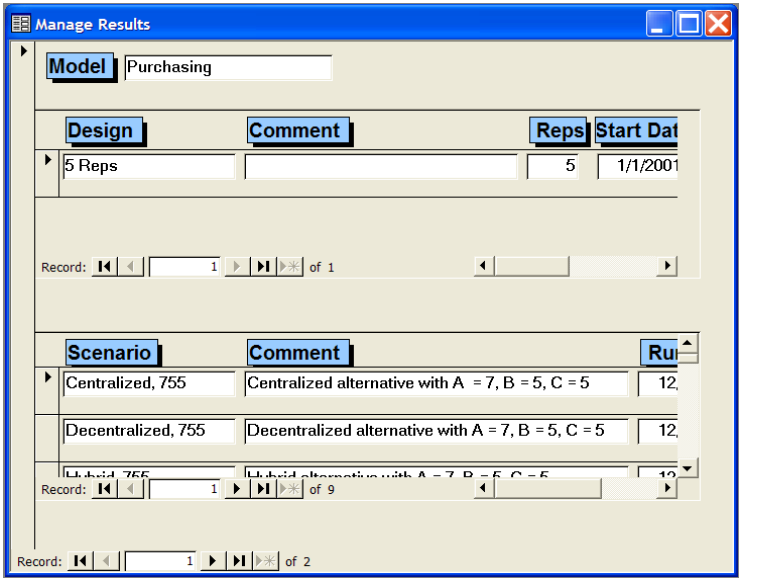
If any of the above change, then a new design name is required. For instance, assume results have been committed to the database with a design name of *Design 1*. After that a Process alternative is added to the model and the model is run again. If the same design name as before is used, SIMPROCESS will prompt for a new design name because the number and names of Process alternatives have changed.



Note that there will be no prompt for a new design name if a different alternative is run that was already in the model. If another alternative is run, the design name or scenario name can be changed. When a design is deleted from the **Design** table, all records associated with that design are removed from the Access database. (In order for this to be true in another SQL database, appropriate relationships and/or constraints must be established when the database is created.) Therefore, to reuse a design name for the same model name (and there has been a design change), first delete the design.

A scenario is used to track various runs of the same system (model) and design. For example, one run might have a certain resource level at 3 while another run has the same resource level at 4. Differentiating those runs in the database is done through the scenario name. The scenario comment field is a good place to document the important settings for that scenario. Again, if a scenario is deleted, all records associated with that scenario will be deleted from the Access database. (As before, in order for this to be true in another SQL database, appropriate relationships and/or constraints must be established when the database is created.)

In the Access database, the **Manage Results** form should be used to delete results for a Model (System), Design, or Scenario. DO NOT modify the tables directly. Using the **Manage Results** form ensures the tables do not become corrupted. This form can be run from the **Forms** tab in Access. Also, when using **Launch Database Application** from the **Report** menu, the **Manage Results** form launches automatically. If the form is blank, then there are no run results in the database.

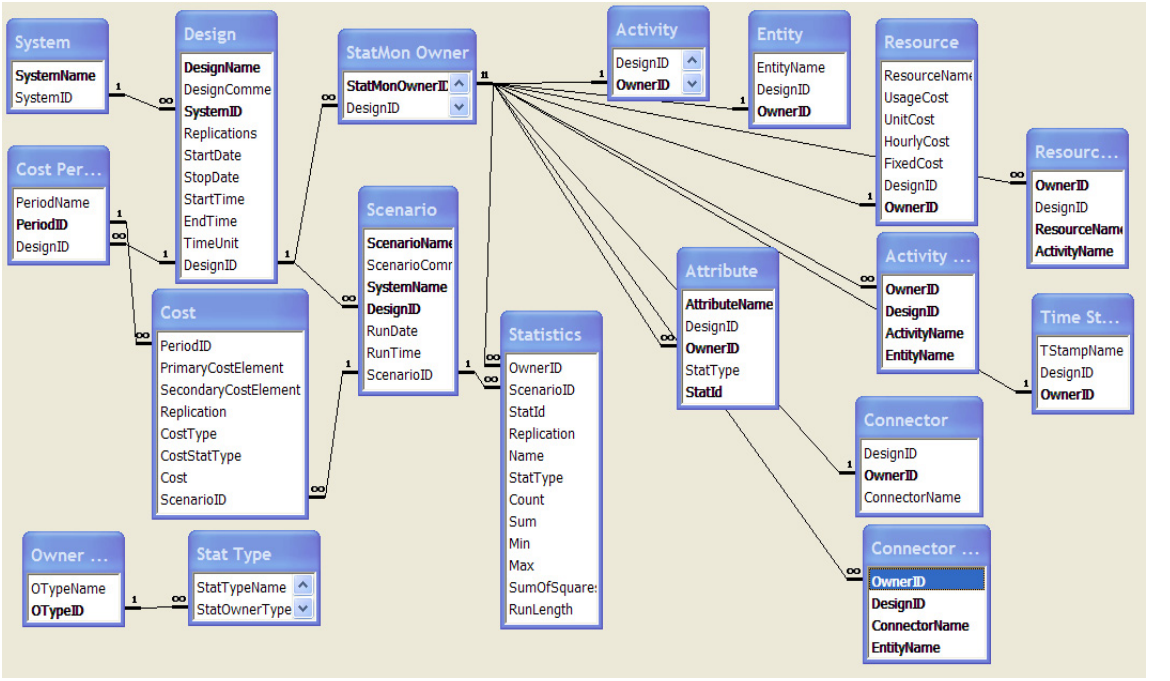


The **Launch Database Application** menu item is only enabled on Windows systems. It will be enabled even if the sProcDB.properties file is configured for a non-Access database.

IMPORTANT: It is good practice to regularly compact the Access database, particularly after deleting records. This can be done from the **Tools** menu of Access by choosing **Database Utilities**.

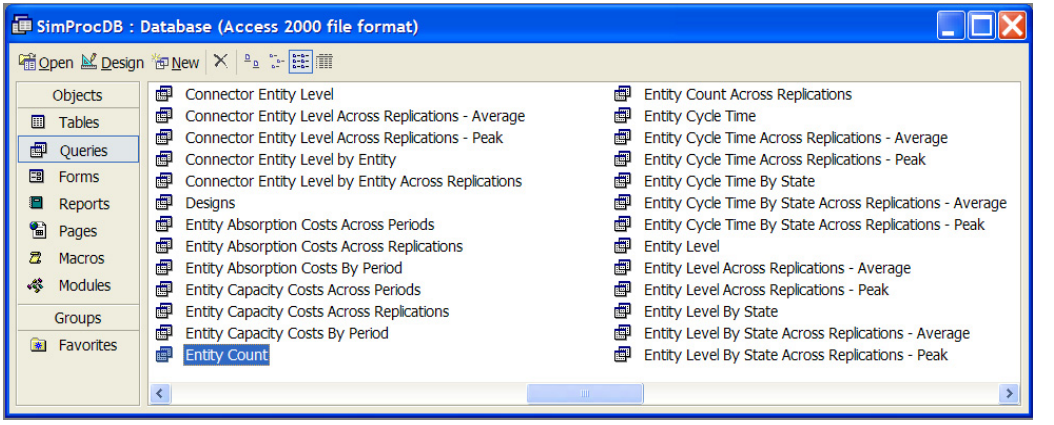
Database Table Relationships

Select **Relationships...** from the **Tools** menu in Access to view all the tables and the relationships between them in the Access database.This is helpful in understanding how the queries were constructed. Because other database tools may or may not support constraints and relationships in the same way as Access, it will be up to the user to create comparable mechanisms there if desired.

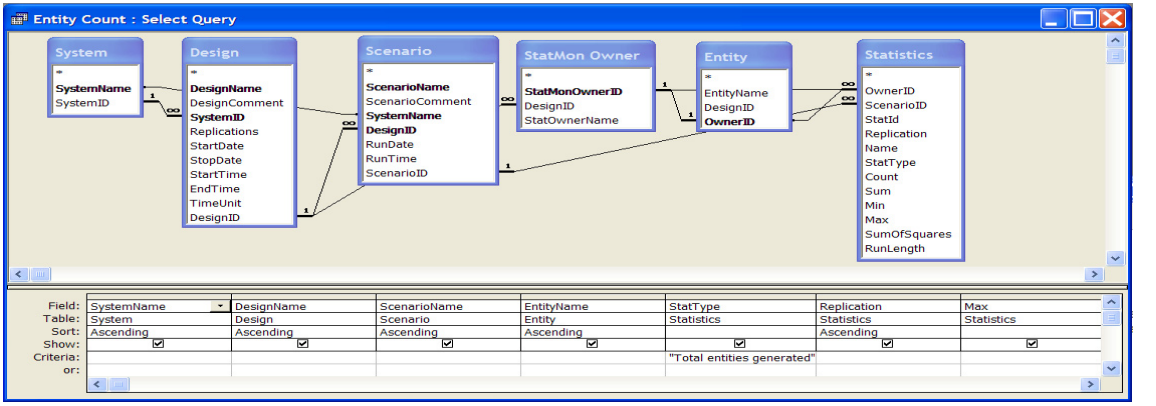


Database Queries

The predefined queries in the SIMPROCESS Access database are designed to offer the same information provided in the Standard Report. (See “Standard Report” on page 186.) The queries can be used as-is or copied and modified. The queries are not restricted by system, design, or scenario. So when the **Entity Cycle Time** query is run, all entity cycle times without restriction will be displayed. Copying a query and restricting its search is one example of tailoring a query for analysis.

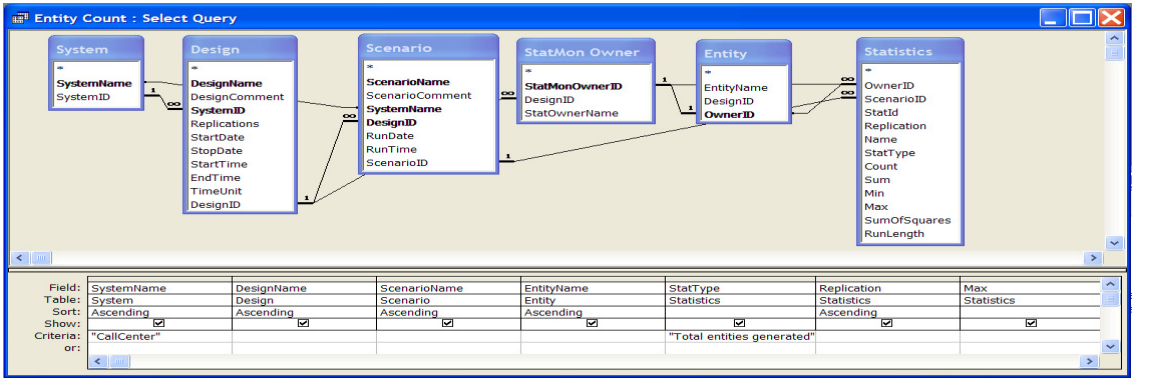


All of the queries were created in Access’ Design View rather than SQL. Shown below is the Design View of the **Entity Count** query.

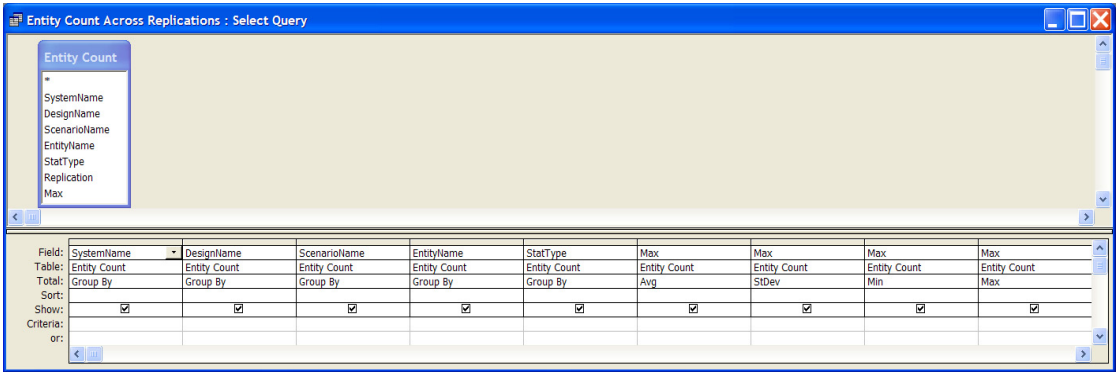


Even though the whole criteria cannot be seen, note that the **StatType** field from the **Statistics** table is restricted by “Total Entities generated” or “Entities remaining in system” or “Total Entities disposed.”

These are the statistics types that make up **Entity Count**. Other fields could be restricted as well. For instance, the **SystemName** field from the **System** table could be restricted so only one model's results would be available. In the example below the query to the demonstration model **CallCenter** is restricted by placing "CallCenter" in the **Criteria** row of the query under **SystemName**.



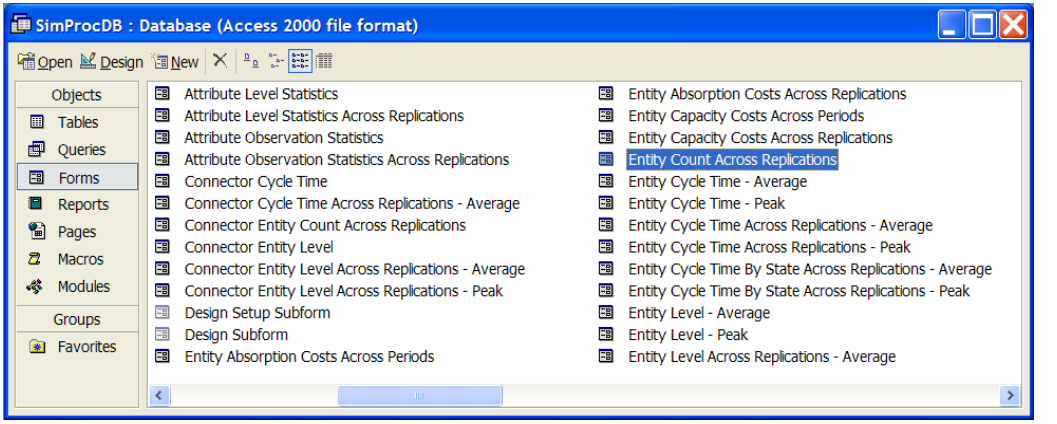
The queries that generate results across replications were developed using the queries that give results by replication. So if the **Entity Count** query is restricted to **CallCenter**, then the **Entity Count Across Replications** query will also be restricted to **CallCenter**. Looking at the Design View for **Entity Count Across Replications**, the only data source for the query is the **Entity Count** query.

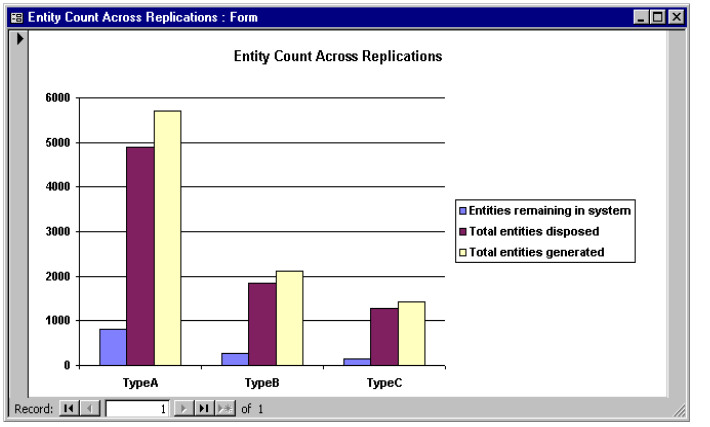


The average, standard deviation, minimum, and maximum were determined by selecting the appropriate statistic in the **Total** row for the field from the **Entity Count** query that was to be summarized across replications. This was accomplished by not including the **Replication** field from the **Entity Count** query.

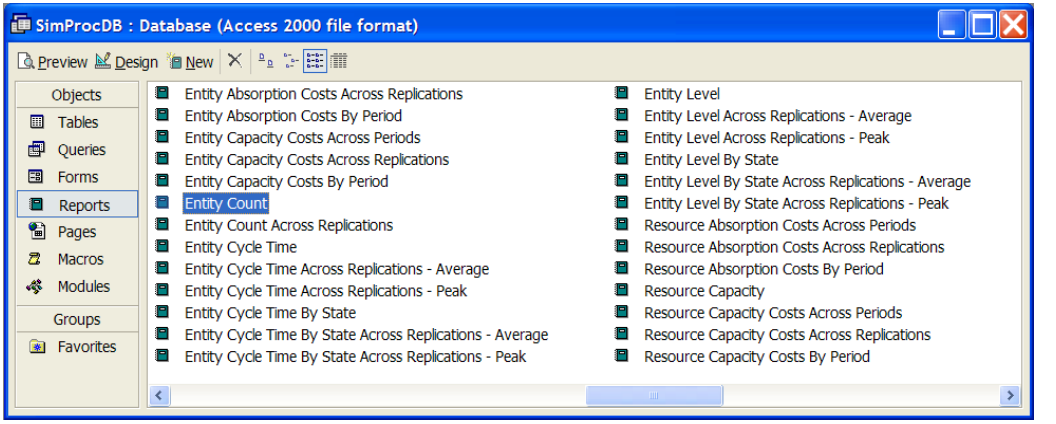
Forms (Graphs) and Reports

The **Forms** tab contains the predefined graphs plus the **Manage Results** form. These graphs are based on the predefined queries. Therefore, the **Entity Count Across Replications** form (or graph) is based on the **Entity Count Across Replications** query. In order to restrict the graph to only certain records, go to the original query (in this case **Entity Count** since **Entity Count Across Replications** is based on it) and restrict it.





The **Reports** tab contains the predefined reports. Like the graphs, the reports are based on the predefined queries. Therefore, the **Entity Count** report is based on the **Entity Count** query. In order to restrict the report to only certain records, go to the original query (in this case **Entity Count**) and restrict it.

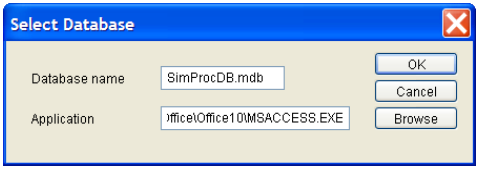


When using a non-Access SQL database, the predefined queries, graphs and reports described in this chapter may serve as a basis for developing SQL statements for retrieving and analyzing database contents. Those using SIMPROCESS on non-Windows systems where the SimProcDB.mdb file is not installed may obtain a copy for reference at the SIMPROCESS web site, or contact SIMPROCESS Technical Support for assistance.

Launch Database Application

This menu item on the **Report** menu (only enabled on Windows systems) brings up a dialog that selects the database and database application to use. SimProcDB.mdb and Microsoft Access are the defaults. (The remaining portion of these instructions assume MS Access is the database application.) If the database field is blank, then Access will start and prompt to open a database. If only a database is in the field (with no path), SIMPROCESS assumes the database is in the `SPUser` directory. If this is not the case, Access will start and prompt for a database. When the database desired is not in `SPUser`, enter the full path, and Access will open with that database.

If SimProcDB.mdb is entered in the database name field, the **Manage Results** form will launch automatically when the database opens. If other actions are desired, simply close the form and continue. Always use the **Manage Results** form to delete records from SimProcDB. If the tables are edited directly, they could become corrupted and run results placed in the database would be lost. The **Manage Results** form can be launched from the **Forms** tab. Copies of SimProcDB.mdb may be used for results. However, the **Manage Results** form will not launch automatically.



SIMPROCESS and Other Databases

Most of this chapter assumes the use of the Microsoft Access database with SIMPROCESS. Those not using Windows will be compelled to use another database, and Windows users may wish to have the flexibility to do so. This section will provide information which those users must know to employ another database for analyzing results.

To store results in any database, SIMPROCESS must have the file `sProcDB.properties` in the `SPUser` directory. The one provided by the installer is configured for use with the Access database. Also included there are two example files which can aid in using another SQL database:

- `mysql.sProcDB.properties`
- `simprocessdb.sql`

The `mysql.sProcDB.properties` file is an example of what needs to be put into the `sProcDB.properties` file in order to use MySQL, a popular open source database, with SIMPROCESS. It contains two required properties and others that are commented.

- `jdbc.drivers` - This property must provide the fully qualified name of a Java class which is a JDBC driver compatible with the database to be used. The one in this example is from the **MySQL Connector/J** driver, available with MySQL at www.mysql.com. The driver must be in the SIMPROCESS classpath at runtime, so the JAR file containing it should be placed into the `jre/lib/ext` directory under the SIMPROCESS installation directory (see "Java Extension Mechanism," beginning on page 603 for more information).
- `jdbc.url` - This property identifies a specific database and is used to connect to it via the driver named above. Details on the possible forms and values of this property will be documented with available Java JDBC drivers. It is important to note, however, that SIMPROCESS will assume that any value beginning with "jdbc:odbc" is the Access database. The example in this file shows using a MySQL database named "simprocess" on the local system.
- `jdbc.username` - This property is disabled in the example. If the database configuration requires a user name, remove the "#" to enable the property and give it an appropriate value.
- `jdbc.password` - This property is disabled in the example. If the database configuration requires a user password, remove the "#" to enable the property and give it an appropriate value.

The `simprocessdb.sql` file is an example of Data Definition Language (DDL) for creating a database in MySQL that is suitable for use with SIMPROCESS. The file contains necessary DDL statements to drop and create a database named "simprocess" and then to create each of the tables needed for storing simulation results, some of which require insertion of static data. While the Access database contains some tables and/or columns with spaces in their names, this DDL uses underscore characters instead. When the value of the `jdbc.url` property does not begin with "jdbc:odbc", SIMPROCESS will use these names to allow support for the widest range of SQL databases. Other features, such as foreign keys, referential integrity, cascading deletes, etc., are not supported by all databases, a fact which should be considered in the management of any selected SQL database.

The DDL statements in this example name the database tables and columns using the same case that SIMPROCESS uses in its internal SQL statements, though not all databases will require or respect case. For instance, testing showed that MySQL server 3.23.52 insisted that table names in SQL statements match the case used in the DDL, while MySQL server 4.0.14-standard allowed the use of all lower case names irrespective of the DDL used.

The included MySQL examples were tested with SIMPROCESS in the following environments:

- SIMPROCESS on Linux, MySQL server 3.23.52 on the same Linux host
- SIMPROCESS on Windows, MySQL server 3.23.52 on a Linux host via LAN
- SIMPROCESS on Windows, MySQL server 4.0.14-standard on a Mac OS X host via LAN

SIMPROCESS users are encouraged to send information to the SIMPROCESS Technical Support team about their own experiences with other non-Access SQL databases. Reports of good (or bad) JDBC drivers for various databases are welcomed. Please send compressed example files similar to these to `simprocess@caci.com`. When sending such reports and/or examples, please be sure and provide as much detail as possible about any special circumstances, platforms involved, etc., and indicate whether it's all right to share any samples with others.

CHAPTER 14

Experiment Manager

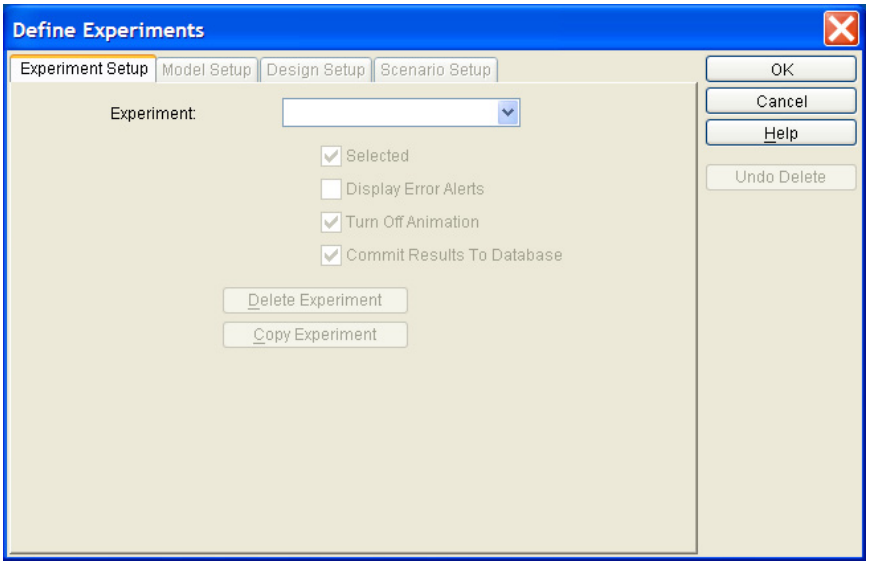
The Experiment Manager sets up model runs that SIMPROCESS will run automatically and, optionally, after each run, place the results in the database. This is accomplished by defining experiments in SIMPROCESS, which are stored in `Experiments.xml` in the `SPUser` directory. SIMPROCESS reads the information from `Experiments.xml`, loads the appropriate model, runs the model, then (optionally) commits the results to the database.

The four items on the **Experiment** menu control the operation of the Experiment Manager.

- Define Experiments
- Run All Experiments
- Run Selected Experiments
- Run Specific Experiment

Defining Experiments

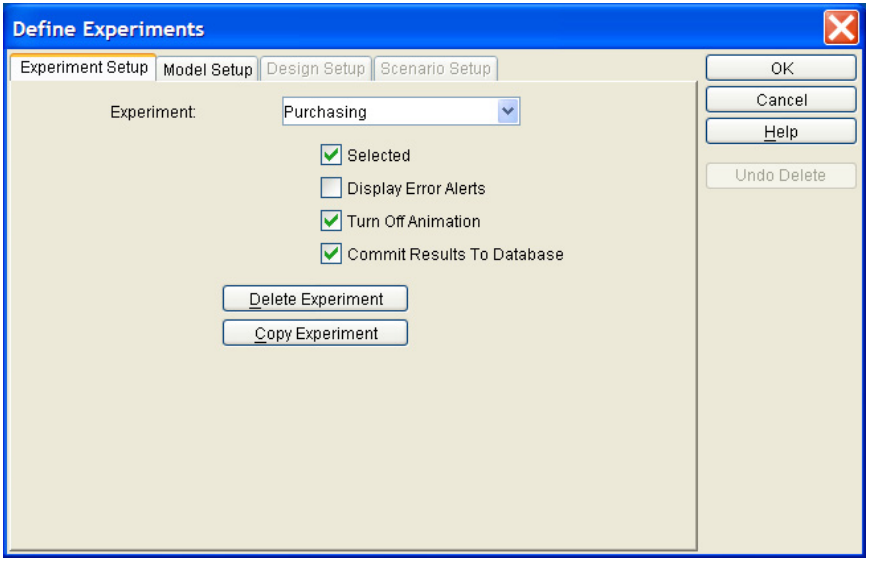
An experiment can have multiple models, a model can have multiple designs, a design can have multiple scenarios, and a scenario can (optionally) have multiple **Model Parameters** (page 242) and **Process Alternatives** (page 84). Selecting **Define Experiments/Using SIMPROCESS...** brings up a dialog experiment information is entered.



If no experiments have been defined, everything is disabled except the **Experiment** combo box. If there are already experiments defined, the first experiment appears in the **Experiment** combo box, and all appropriate items are active. To add to or modify an experiment already defined, select an experiment from the **Experiment** combo box. There may be a slight delay when a predefined experiment is selected. This is because the first model for the experiment must be loaded and then processed.

Entering Experiment Information

There are five fields that require entries for each experiment: **Experiment**, **Selected**, **Display Error Alerts**, **Turn Off Animation**, and **Commit Results To Database**. This shows an example experiment called **Purchasing**. Type the name in the **Experiment** combo box, then press **Enter**. If not already active, entering an experiment name causes the remaining items on the **Experiment Setup** tab and the **Model Setup** tab to activate.

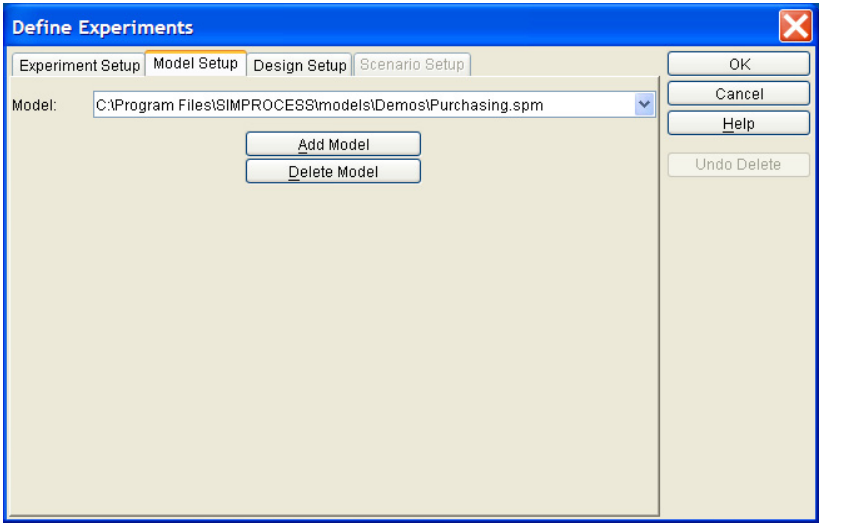


Once the experiment has been named, then check or uncheck **Selected**. The default is checked. **Selected** is used as an option for running experiments. **Display Error Alerts** defaults to unchecked. If unchecked, then SIMPROCESS will run the experiment without stopping to notify of errors. This means SIMPROCESS will run every combination of model, design, and scenario that it can. Those with errors will be skipped over. If **Display Error Alerts** is checked, when SIMPROCESS encounters an error when running the experiment, an error dialog will display that will stop the experiment until the error has been acknowledged by the user. **Turn Off Animation** defaults to checked. If checked, all models in the experiment will run with animation turned off. **Commit Results To Database** defaults to checked as well. When selected, the results from each run will be placed in the SIMPROCESS database. Multiple experiments can be entered. Although not necessary, it is recommended that model, design, and scenario information be entered before adding another experiment.

Entering Model Information

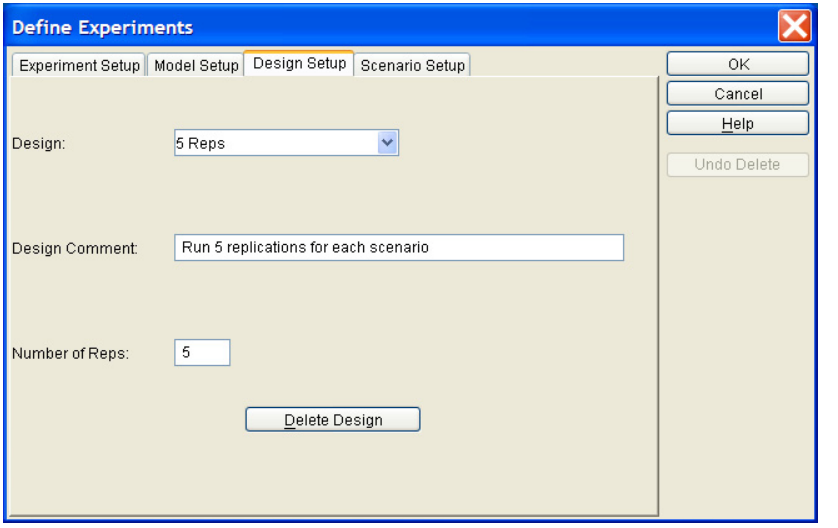
The next tab is **Model Setup**. This tab is active when an experiment name is entered or selected on the **Experiment Setup** tab. To select a model, click the **Add Model** button. This brings up a file chooser dialog. The complete path and the name of the model selected is added to the **Model** combo box. All models added are part of the experiment that was selected on the **Experiment Setup** tab. Although multiple models can be entered before entering design and scenario information, it is recommended that all the design and scenario information (along with parameter and process information, if needed) be entered before entering the next model. If the selected model is moved after being added to an experiment, the model and all associated experiment information (design, scenario, etc.) will be deleted from the experiment the next time **Define Experiments/Using**

SIMPROCESS... is selected.



Entering Design Information

The **Design Setup** tab is active when a model is selected in the **Model** combo box on the **Model Setup** tab. At least one design name is required for each model. The **Design Comment** and **Number of Reps** fields are optional. If no value (integer only) is entered for **Number of Reps**, the last saved model value will be used for each scenario in this design unless there was a previous design for the same model. One design called “5 Reps” is entered for the model `C:\Program Files\SIMPROCESS\models\Demos\Purchasing.spm`.



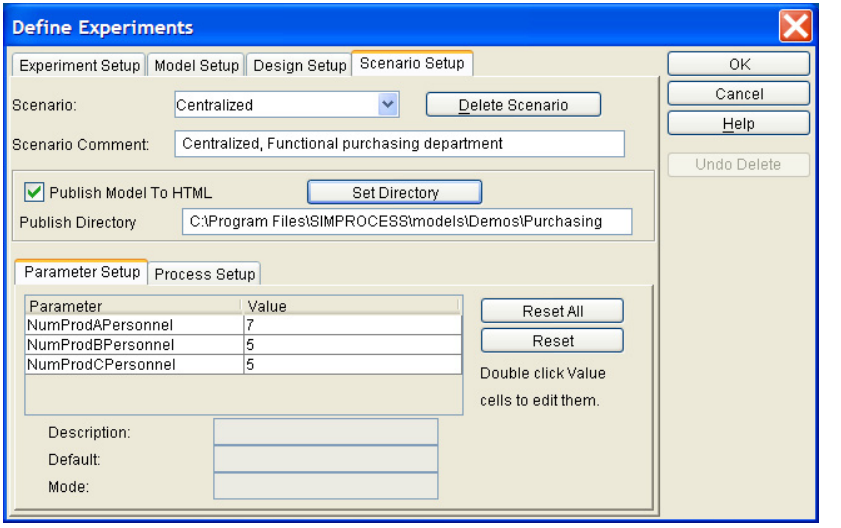
Entering Scenario Information

The **Scenario Setup** tab is active when a design is selected in the **Design** combo box on the **Design Setup** tab. At least one scenario must be entered for each design. If creating a new scenario, a name for the scenario must be entered in the **Scenario** combo box. The **Scenario Comment** field is optional. At this point no more information is required to run a scenario.

Publishing the results of this scenario run to HTML is optional. If **Publish Model To HTML** is selected, a value for **Publish Directory** must be entered. The **Publish Directory** is the destination directory for the HTML output. The name of the directory created for the HTML files is the model name with any spaces replaced by underscores. If a directory with this name already exists within the selected destination directory, either select another destination directory, or rename, move, or delete the existing directory. For instance, in the example below, the directory of the model `Purchasing.spm` was selected as the destination directory. This means the publish process will create a directory named `Purchasing` within the `Purchasing` directory. If a directory named `Purchasing` already existed in `C:\Program File\SIMPROCESS\models\Demos\Purchasing`, an error would occur. So for this example, the HTML files will go in the `C:\Program Files\SIMPROCESS\models\Demos\Purchasing\Purchasing` directory. Thus, if multiple runs of the same model are to be published, a unique destination directory will need to be assigned for each scenario. Usually, if used at all, only one scenario for each model is published to HTML.

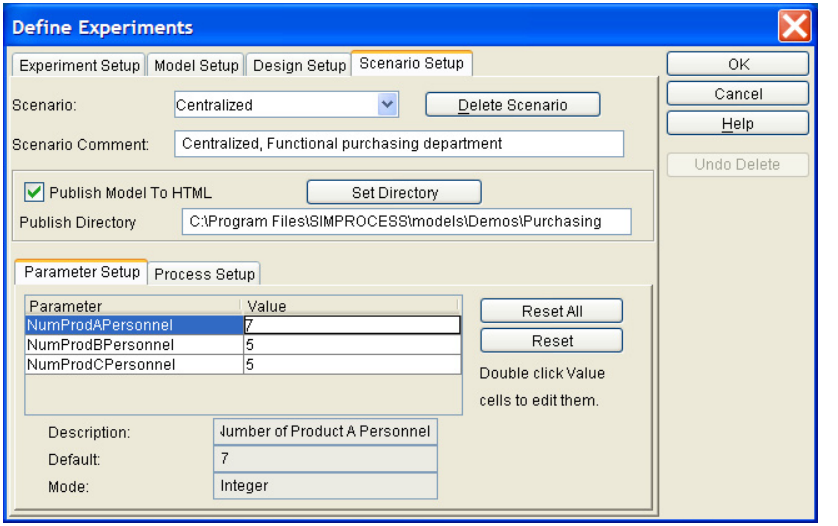
Setting **Model Parameter** values and **Process Alternatives** is optional. If these are not set, then the last saved value for each **Model Parameter** and **Process Alternative** are used. **Model Parameters** are set on the **Parameter Setup** tab, and **Process Alternatives** are set on the **Process Setup** tab. These tabs are part

of the **Scenario Setup** tab.



Entering Model Parameter Information

The **Parameter Setup** tab is used to enter **Model Parameter** values. The attributes for the selected model that have been designated as **Model Parameters** appear in the table. When a **Model Parameter** is selected, its description (comment from the attribute definition), mode (Integer, Real, or String), and default value are displayed in the text fields below the table. Once selected, the value can be changed by typing into the field on the table. Values entered that do not match the mode will not be accepted. The **Reset** button will reset the selected **Model Parameter** to its default value. The **Reset All** button resets all **Model Parameters** to their default values. In this example there are three Model attributes that can be changed for a scenario. (When changing selected scenarios, there may be a slight lag for the **Model Parameter** values to update. This is due to the processing required to update the values.)

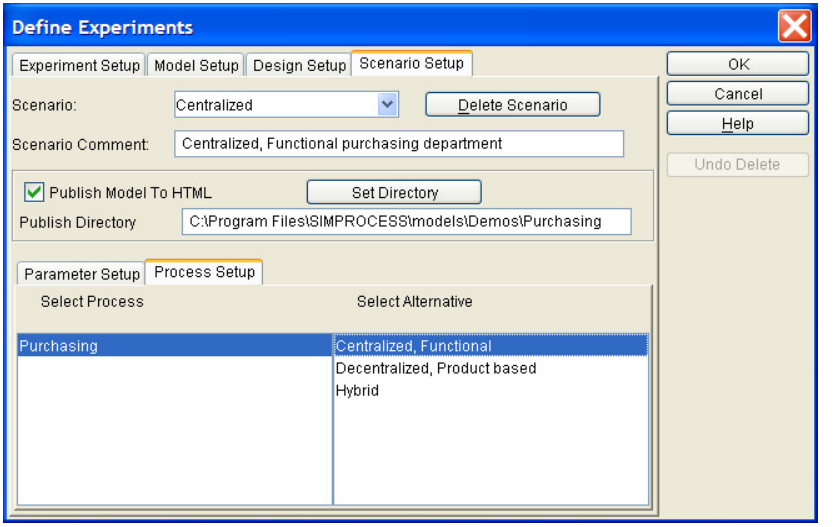


NOTE

If no **Model Parameter** information is entered for a scenario, then the model will run with the last saved values for the **Model Parameters**. If a parameter has been changed for a scenario, and the next scenario uses the same model (that is, a new model is not loaded), then the **Model Parameter** will have the same value as the previous scenario. It will not reset to its default value.

Entering Process Alternative Information

The **Process Setup** tab is used to set the active alternatives for processes that have more than one alternative. The panel on the left displays the processes in the selected model that have more than one alternative. (Since processes are displayed by name, it is recommended that process names not be duplicated within a model.) Once a process is selected, the alternatives for that process will appear in the panel on the right. If an alternative has already been selected, that alternative will be highlighted. If no alternative is highlighted then the model will run with the alternative that was active during the last save of the model. Select the alternative to be active for the current scenario.



In this example the **Centralized, Functional** alternative for the **Purchasing** process will be active for the current scenario.

NOTE

If no process/alternative information is entered for a scenario, then the model will run with the last saved active alternative for each process. If an alternative has been changed for a scenario, and the next scenario uses the same model (that is, a new model is not loaded), then the active alternative for a process will be the same as the previous scenario unless a different alternative is specified in the Experiment Manager.

Undo Delete Button

The **Undo Delete** button is active whenever an experiment, model, design, or scenario has been deleted. The button remains active until used or until the scope of the deleted item has been lost. An experiment can be restored any time before another delete occurs. A model can be restored as long as the experiment to which it belongs remains the selected experiment. A design can be restored as long as the experiment and model to which it belongs remain selected. Finally, a scenario can be restored as long as the experiment, model, and design to which it belongs remain selected.

Running Experiments

Once the experiments have been defined, run the experiments. This section discusses starting experiments, the operation of experiments, how to interact with experiments, and how to generate standard reports from experiments.

Starting Experiments

There are three options for running experiments.

- Run All Experiments
- Run Selected Experiments
- Run Specific Experiment

Run All Experiments

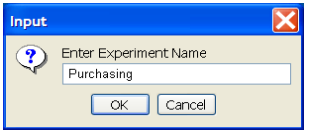
The menu item **Run All Experiments** causes SIMPROCESS to attempt to run every experiment defined. This option ignores the **Selected** field.

Run Selected Experiments

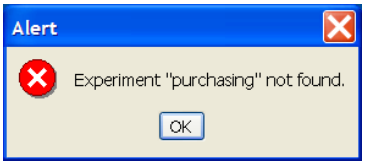
When this menu item is selected, SIMPROCESS attempts to run the experiments in which the **Selected** field is checked.

Run Specific Experiment

This menu item specifies one experiment to run. When selected, enter the experiment name in the dialog.



If no match occurs, an error message appears stating the experiment could not be found in the database. Case does matter when selecting a specific experiment. The case and spelling must match.


Alert
Experiment "purchasing" not found.
OK

Experiment Operation

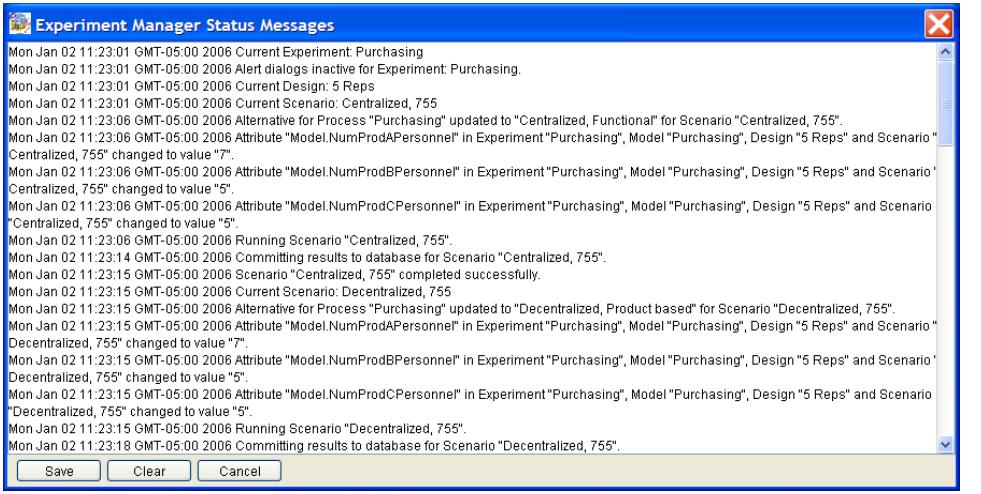
The Experiment Manager operates as follows when running experiments:

Once an experiment begins, SIMPROCESS begins a sequence of steps. Each step occurs if the previous completes successfully. The steps to running experiments are:

1. Load Experiments.xml.
2. Prompt to save current work if necessary.
3. Enter a loop with sub loops.
    Find Experiment.
        Find Model.
            Find Design.
                Find Scenario.
                Find Parameters.
                Find Process Alternatives.
                Load Model.
                Verify Design.
                Run Model.
                Commit results to database.
                End loop.
            End loop.
        End loop.
    End loop.
4. Display status message on success of experiments.

Experiment Trace

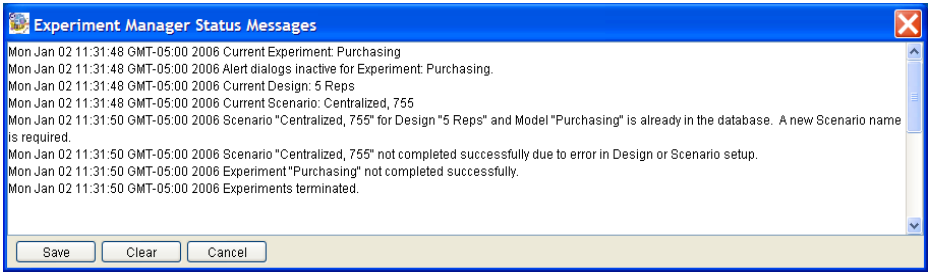
During experiment execution, the Experiment Manager displays a trace showing the steps that have been completed and the current step. The trace includes the date, time, and a message.



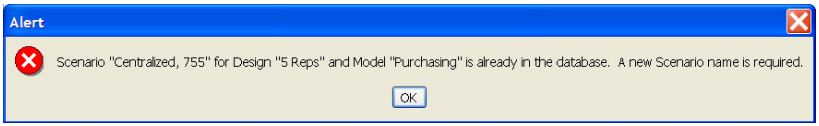
It is important to examine the Experiment Manager trace, since it will give the complete status of the experiments. The above example shows the experiment, alert dialog status (see below), model, design, and scenario. Also, it shows the **Process Alternatives** that were active and the values of the **Model Parameters** for the scenario.

Experiment Errors

As explained in the instructions for defining experiments, when the **Display Error Alerts** field is not selected, interactive error messages are suppressed. However, error messages will appear in the Experiment Manager trace. The Experiment Manager trace shows which experiments completed successfully and which encountered errors. Especially important are the messages that show errors with the **Model Parameters**.



When the **Display Error Alerts** field is selected, error dialogs will appear that pause the Experiment until the error is acknowledged.



Also, after the error displays, if there are more experiments to be run, a dialog appears with the option to stop all experiment runs.

If experiments are to be run overnight, it is recommended that the **Display Error Alerts** field not be selected for every experiment that is to be run. That way SIMPROCESS will run every combination of Experiment, Model, Design, and Scenario that it can. Otherwise, if an error occurs, processing stops until the error is acknowledged.

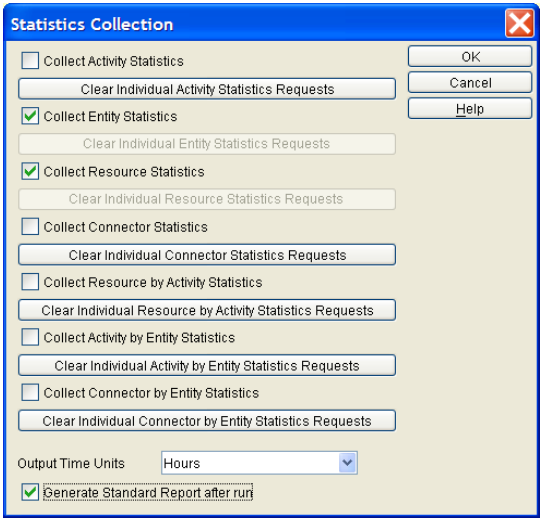
Interacting With Experiments

A model run by the Experiment Manager can be interacted with in the same manner as a model that was user initiated. This means the animation can be turned on or off, the animation settings can be changed, the model can be navigated, etc.

Experiments can be stopped early by stopping a model run. An experiment cannot be stopped while loading experiment information, loading a model, or committing results to the database. If the **Display Error Alerts** field is selected, there will be an option to stop completely. Otherwise every run must be stopped to stop all experiment, model, design, and scenario combinations.

Generating Standard Reports From Experiments

If selected, the Experiment Manager automatically commits the run results to the database. If an ASCII version of the Standard Report is needed, go to **Define Global Statistics Collection** on the **Report** menu. Select **Generate Standard Report after run**. This will create a file in the model's directory that will contain the report for every replication, the sum of the replications, and the average of the replications.


Statistics Collection
OK
Cancel
Help
Collect Activity Statistics
Clear Individual Activity Statistics Requests
Collect Entity Statistics
Clear Individual Entity Statistics Requests
Collect Resource Statistics
Clear Individual Resource Statistics Requests
Collect Connector Statistics
Clear Individual Connector Statistics Requests
Collect Resource by Activity Statistics
Clear Individual Resource by Activity Statistics Requests
Collect Activity by Entity Statistics
Clear Individual Activity by Entity Statistics Requests
Collect Connector by Entity Statistics
Clear Individual Connector by Entity Statistics Requests
Output Time Units
Hours
Generate Standard Report after run

CHAPTER 15

OptQuest for SIMPROCESS

In today's highly competitive global environment, people are faced with many difficult decisions, such as allocating financial resources, building facilities, managing inventories, determining product mix strategies, and more. Modeling a decision problem in SIMPROCESS discovers what performance measures can be expected using a certain strategy.

A strategy can be defined as a certain set of values for the model parameters. Other words for strategy include scenario and solution. Note that "solution" refers to the model parameter values (inputs to the simulation), *not* the resulting values of the performance measures.

Suppose the goal was to find the best strategy (without using OptQuest). Model parameter values for a strategy being considered would have to be entered into SIMPROCESS and the results analyzed. Then, this process would have to be repeated for every strategy under consideration. (Experiment Manager automates running models with various values for model parameters. See "Experiment Manager" on page 387.) Often, it would not be clear how to adjust the model parameters from one simulation to the next. This type of search is tedious and, in problems with thousands or millions of potential alternatives, impractical.

OptQuest enhances SIMPROCESS by automating the search for an optimal strategy.

Note that OptQuest for SIMPROCESS is licensed separately from SIMPROCESS.

Overview of OptQuest for SIMPROCESS

Since OptQuest is an optimization tool, it is attempting to minimize or maximize the value of a performance measure based on limits (constraints, upper bounds, and lower bounds). OptQuest automatically runs SIMPROCESS models varying the values for the model parameters searching for optimum results within the specified limits.

When the optimization runs:

OptQuest feeds a potential solution into SIMPROCESS model by setting the decision variable (model parameter) values.

SIMPROCESS runs one simulation (which may include multiple replications) to evaluate the solution.

OptQuest takes the resulting response values from SIMPROCESS.

OptQuest analyzes the results of the simulation and uses its intelligent search procedures to generate a new potential solution, which it then sends to SIMPROCESS.

OptQuest repeats this process. Its ultimate goal is to find the solution that optimizes (maximizes or minimizes) the value of the model's objective.

Elements of an OptQuest Optimization

Optimizations consist of an objective (minimize or maximize), decision variables, and constraints (constraints are optional).

Objective: An expression that represents the model's objective, such as minimizing queues or maximizing profits.

Decision Variables: Variables that can be meaningfully manipulated to affect the performance of a simulated system. The model parameters in SIMPROCESS are called decision variables in OptQuest.

Constraints: Relationships among decision variables and output variables. For example, a constraint might ensure that the total amount of money allocated among various investments cannot exceed a specified amount, or the processing time of a system cannot be greater than a certain value.

There can be bounds (upper and lower) on the decision variables and performance measure constraints (statistics).

Using OptQuest: An Overview

Follow these steps to use OptQuest.

Create a simulation model, or open a simulation model.

Prepare the model for optimization. This includes creating and assigning model parameters, establishing a performance measure to optimize, making sure the model is complete, verifying and validating the model, and making sure the model runs with no errors.

Set up the optimization, or select previous optimization settings (**Tools/OptQuest** menu). The following steps apply to creating a new optimization. Previously defined optimization settings can be modified or deleted.

a. Define the objective.

b. Select the decision variables.

c. Define constraints.

d. Set process alternatives.

e. Select optimization options.

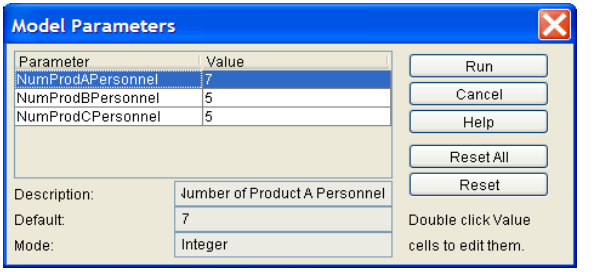
Run the optimization. When **Start** is selected, the model is saved, and the OptQuest interface appears. From this interface the user can monitor the optimization, stop the optimization, and create reports once complete. Also, if selected, OptQuest will prompt for more iterations when approaching the maximum iteration.

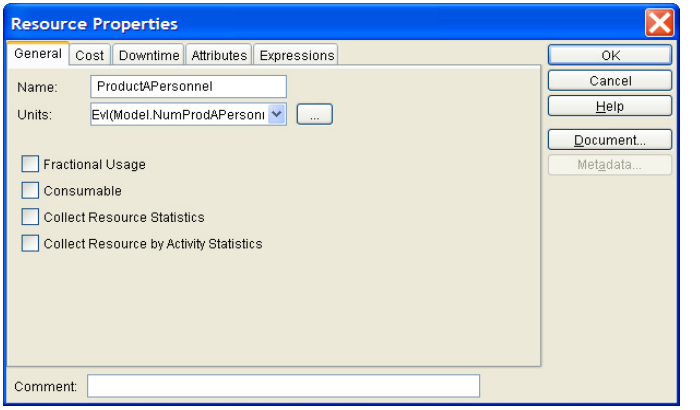
Interpret the results.

Optimization Setup

Preparing for Optimization

In order to use OptQuest with a model, the model must have model parameters of type Integer and/or Real. Model parameters are user controlled values that typically set some of the initial conditions of a simulation. For instance, if Truck is a resource in the model, a model parameter could be used to set the number of the resource Truck available. In the Inventory demonstration model (see *SIMPROCESS Getting Started Manual*) reorder levels are controlled by model parameters. When a model is run that has model parameters, a dialog appears that allows values of the model parameters to be changed before the run begins. The image below shows the model parameter dialog from the Purchasing demonstration model. There are three model parameters: `NumProdAPersonnel`, `NumProdBPersonnel`, and `NumProdCPersonnel`. All three of these are Model Attributes and their **Mode** is Integer. These model parameters set the number of units of the resources ProductAPersonnel, ProductBPersonnel, and ProductCPersonnel.





Since OptQuest uses the Integer and Real model parameters as decision variables, when OptQuest runs the model as part of the optimization, it sets the values of the model parameters for each run.

Another requirement for optimization is an objective. Therefore there must be a performance measure in the model to maximize or minimize. This performance measure could be one of the standard statistics collected by SIMPROCESS or a specialized statistic, which could consist of a linear or non-linear combination of various standard statistics. Again, referring to the Purchasing demonstration model, the objective is to minimize the capacity cost of all the resources. Since capacity cost is collected automatically, this statistic does not have to be created. However, in the Inventory demonstration model, the objective is to minimize inventory and minimize the cycle time of an order. Since only one value can be optimized, these performance measures must be combined into one. In the Inventory demonstration model there is a linear combination of the two performance measures. This combination is in the **End Simulation** expression of the **Model Expressions** (**Define/Model Expressions**).

```
Model.OrderTime := GetEntityStatistic("Order", "tokendelay", "Avg",
Replication);
Model.FinishedProduct := GetResourceStatistic("FinProduct",
"resrcidle", "Avg", Replication);


Model.InventoryPlusOrderTime := Model.FinishedProduct + (5.0 *
Model.OrderTime);
```

When combining performance measures the Expression language will be needed to retrieve statistics collected during the simulation. (See “Accessing Statistics During Simulation” on page 308.) The example above shows values being assigned to three Model Attributes: `OrderTime`, `FinishedProduct`, and `InventoryPlusOrderTime`. `OrderTime` is assigned the average cycle time for the entity **Order**. `FinishedProduct` is assigned the average number of units idle of the resource **FinProduct**. `InventoryPlusOrderTime` is a linear combination of the two, and statistics are collected for that attribute. Thus, the Model Attribute `InventoryPlusOrderTime` is the value to minimize. Note that the System Attribute `Replication` is used to get the value from the appropriate replication of the simulation.

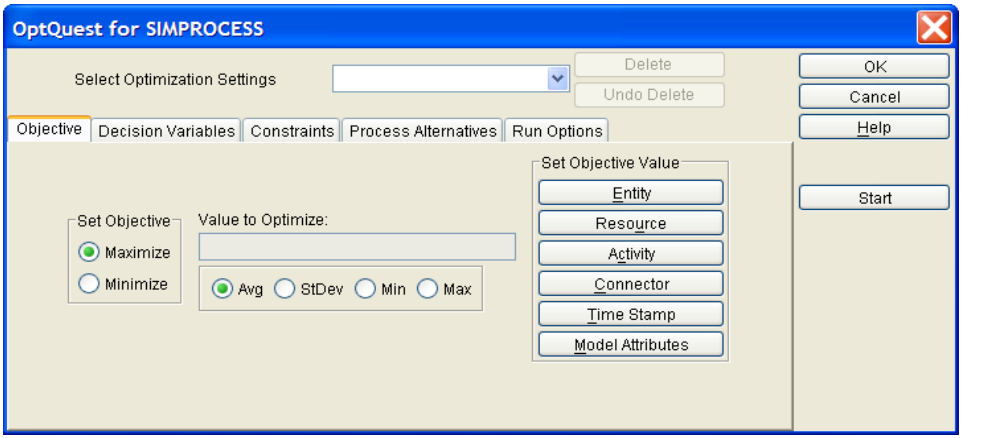
Standard or specialized statistics can also be used as constraints in OptQuest. Therefore, if performance measures need to be used as constraints, make sure the appropriate statistics are being collected. For example, the values being assigned to `OrderTime` and `FinishedProduct` are also constraints in the Inventory demonstration model.

The final steps in preparing a model for optimization apply whether or not OptQuest is intended to be used. Make sure the model is complete. That is, all required fields in properties dialogs have been defined (especially if portions of the model have come from other models), and all activities and processes are connected. Run the model for several replications to ensure there are no errors. Determine the appropriate number of replications needed to achieve statistical significance. Finally, and most importantly, make sure the model accurately reflects the system being modeled.

Defining An Optimization

Optimizations can only be defined for the currently active model in SIMPROCESS. Thus, if the model to optimize is not loaded, load it; or if already loaded, make sure the model to optimize is the active model.

Select **Tools/OptQuest**. (If **OptQuest** is not enabled, contact the SIMPROCESS Sales Manager to purchase a license for OptQuest for SIMPROCESS.) This brings up the OptQuest for SIMPROCESS setup dialog.



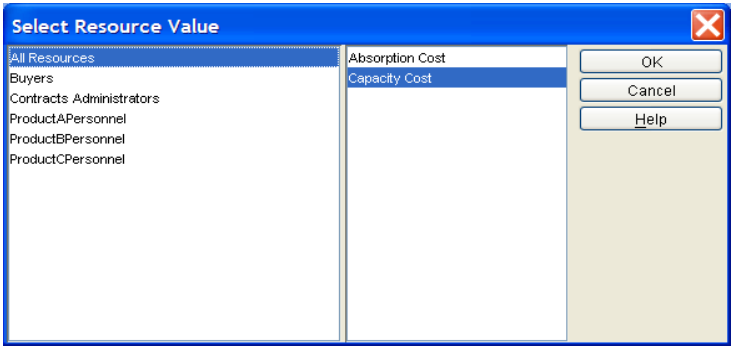
If no optimizations have been created for the model, **Select Optimization Settings** will be empty. The first step in defining an optimization is to give it a name. Enter a name in **Select Optimization Settings**. If there are already other optimization settings defined, entering a new name creates a new setting. To switch between settings, simply select the desired setting from **Select Optimization Settings**.

Once a name has been entered, continue defining the optimization. There are five tabs on the dialog: **Objective**, **Decision Variables**, **Constraints**, **Process Alternatives**, and **Run Options**. The tabs can be edited in any order.

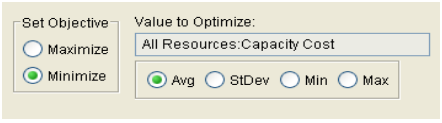
Objective

The **Objective** tab sets whether to **Minimize** or **Maximize** and the value to optimize. The buttons on the right are used to select the value to optimize. **Entity**, **Resource**, **Activity**, **Connector**, **Time Stamp**, or **Model Attribute** values can be optimized. For the Purchasing demonstration model, the objective is to minimize the capacity cost of all the resources. So **Minimize** was selected, then the **Resource** button was selected

to choose the appropriate value to minimize.



On the left are all the resources defined in the model, plus an additional item named **All Resources**. When an item is selected on the left, the possible values are displayed on the right. In this example, **All Resources** is selected on the left and **Capacity Cost** on the right. When **OK** is selected, **All Resources:Capacity Cost** appears in **Value to Optimize**. (In the Inventory model, the **Value to Optimize** is **Model.InventoryPlusOrderTime:Value**.)



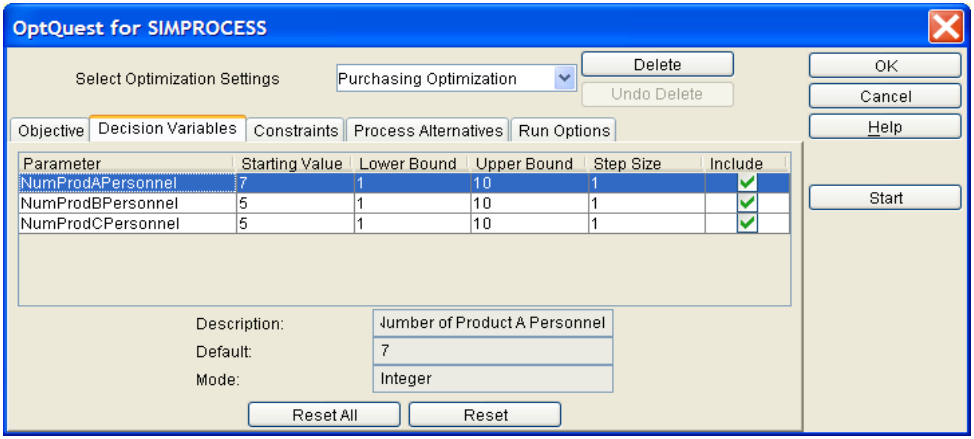
There are four options for the **Value to Optimize**: **Avg** (Average), **StDev** (Standard Deviation), **Min** (Minimum), and **Max** (Maximum). For this example, the average capacity cost for all the resources is needed. Since stochastic (random) simulation models should be run for more than one replication, the capacity cost of all resources for each replication is averaged.

Note about Min and Max: Min or Max should only be used when the constraints should bring convergence. For instance, if minimizing the maximum wait time was the goal, **Max** should be chosen for the **Value to Optimize**. Doing that, though, assumes there are constraints that would limit the maximum.

Decision Variables

The Decision Variables tab contains a table similar to the table on the Model Parameters dialog. This table lists all the model parameters in the model (no matter what **Mode**). However, only those model parameters whose **Mode** is Integer or Real are decision variables. The **Starting Value** is the value OptQuest will use on the first iteration. If new values are not entered, the **Starting Value** is the default value of the model parameter assigned at the time the attribute was defined. The last column of the

table, **Include**, determines which decision variables OptQuest will modify during the optimization. The remaining columns, **Lower Bound**, **Upper Bound**, and **Step Size** apply only to model parameters whose **Mode** is Integer or Real. If the model parameter is not one of those modes, N/A will be entered in appropriate cell. Also, if the **Mode** is Real, N/A will be entered in the **Step Size** column of that row. If **Lower Bound** is left blank, negative infinity is assumed. Likewise, if **Upper Bound** is left blank, infinity is assumed. The **Reset** and **Reset All** buttons work as on the Model Parameters dialog. These buttons only apply to the **Starting Value** column.



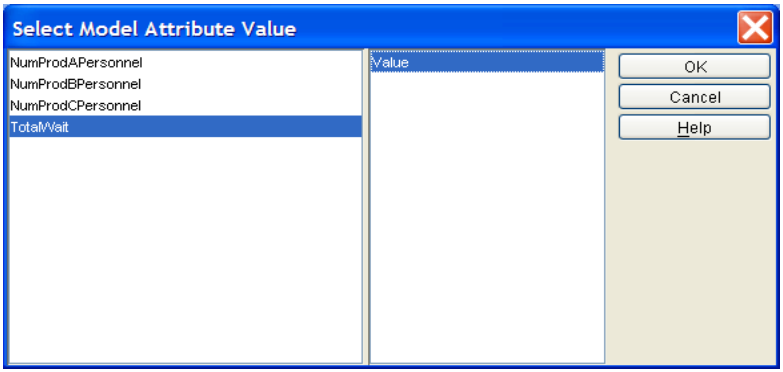
Constraints

The **Constraints** tab is where constraints are defined. (Constraints are not required for an optimization, but are usually used in an optimization.) Two types of constraints can be defined. The first type is a constraint on a performance measure of the model. The **Entity**, **Resource**, **Activity**, **Connector**, **Time Stamp**, and **Model Attributes** buttons work as on the **Objective** tab. These buttons allow performance measures to be selected for constraint. Unlike the **Objective**, though, which can only be one performance measure, more than one performance measure constraints can be added to the optimization. Also, on performance measure constraints, there is an **Upper Bound** and/or a **Lower Bound**. (Note: If there are no bounds for a performance measure, do not include it as a constraint.) In the Purchasing model there is a Model Attribute named `TotalWait`. This attribute represents the total amount of time all entity types (Product A, Product B, and Product C) wait for resources. The code below is from the **End Simulation** expression of the **Model Expressions** (**Define/Model Expressions**).

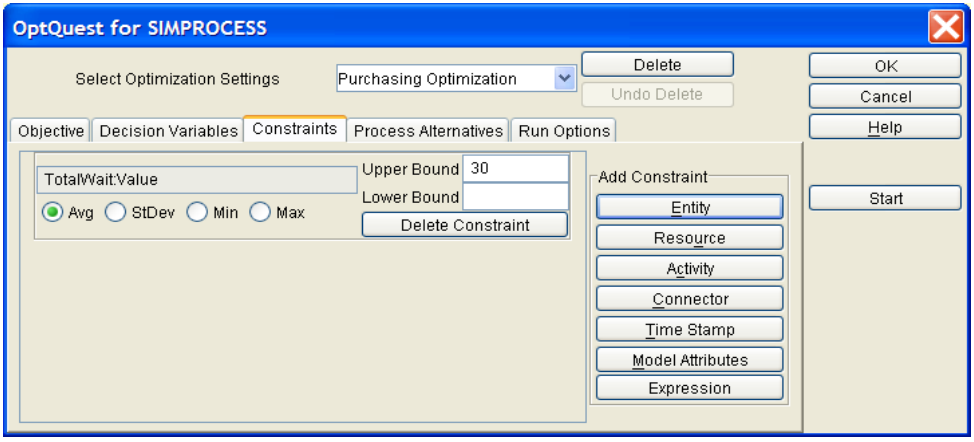
```
aWait, bWait, cWait : REAL;
aWait := GetEntityStatistic("Product A", "tokenwaitdelay", "Avg",
Replication);
bWait := GetEntityStatistic("Product B", "tokenwaitdelay", "Avg",
Replication);
```

```
cWait := GetEntityStatistic("Product C", "tokenwaitdelay", "Avg",
Replication);
Model.TotalWait := aWait + bWait + cWait;
```

The local variables `aWait`, `bWait`, and `cWait` contain the average wait time for Product A, Product B, and Product C respectively. The Model Attribute `TotalWait` contains the sum of all the waits. Selecting the **Model Attributes** button brings up the list of the Model Attributes in the Purchasing model. `TotalWait` was selected, then `Value` was selected.



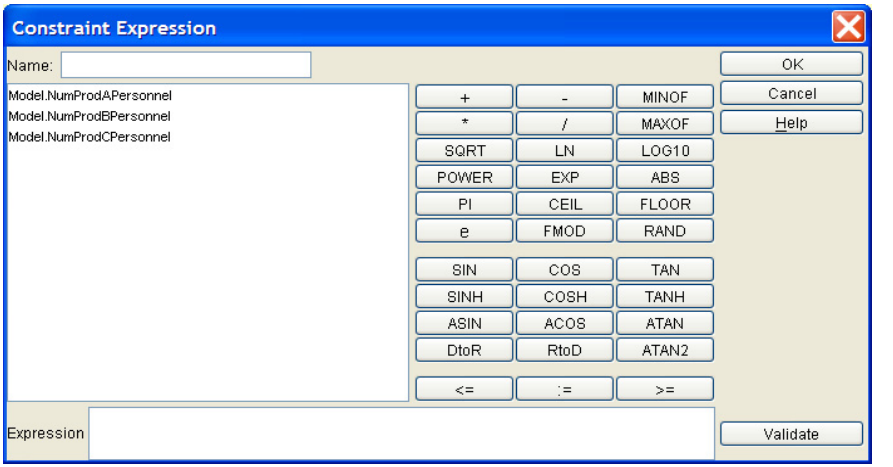
Performance measure constraints appear as the objective except an **Upper Bound** field, a **Lower Bound** field, and a **Delete Constraint** button are added.



As with the decision variables, a blank **Lower Bound** assumes negative infinity, and a blank **Upper Bound** assumes infinity. Once a performance measure constraint has been added, only the **Upper Bound**, **Lower**

Bound, and type of statistic can be edited. If the type of value chosen needs to be changed, the constraint must be deleted and recreated.

The second type of constraint is an expression constraint. An expression constraint defines mathematical relationships between decision variables. The **Expression** button is used to create expression constraints. This button displays a dialog that lists the decision variables on the left and the allowed mathematical operators and functions on the right. The example below shows the Purchasing model. Note that the decision variable names must be the fully qualified SIMPROCESS attribute name. That is, the type of the attribute (Model, Entity, etc.) must be included.



A name must be entered for the constraint in the **Name** field. Names for expression constraints within the same optimization setting must be unique. The expression can be typed directly into the **Expression** text area, or by clicking on the decision variable or mathematical operator or function. The syntax is the same as used in the SIMPROCESS Expression language. Some mathematical functions allowed by OptQuest are not allowed in the SIMPROCESS Expression language, therefore all of the functions allowed by OptQuest are listed in the following table along with descriptions.

Expression Constraint Functions

Function	Description
ABS(x)	Returns the absolute value of x.

Expression Constraint Functions

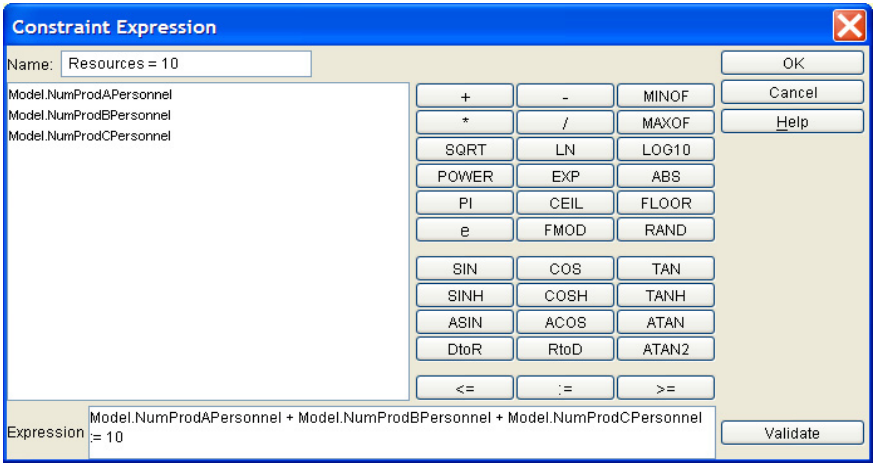
Function	Description
ACOS(x)	Returns the arccosine of x in the range 0 to n radians. x is between -1 and 1.
ASIN(x)	Returns the arcsine of x in the range –n/2 to n/2 radians. x is between -1 and 1.
ATAN(x)	Returns the arctangent of x in the range of –p/2 to p/2 radians. If x is 0, atan returns 0.
ATAN2(x, y)	Returns the arctangent of y/x in the range –pi to pi radians. If both parameters of ATAN2 are 0, the function returns 0.
CEIL(x)	Returns the smallest whole number greater than or equal to x.
COS(x)	Returns the cosine of x, where x is an angle in radians.
COSH(x)	Returns the hyperbolic cosine of x, where x is an angle in radians.
DtoR(x)	Converts degrees to radians.
e	Mathematical constant e, approximately equal to 2.718.
EXP(x)	Returns *e* raised to the x power.
FLOOR(x)	Returns the largest whole number less than or equal to x.
FMOD(x, y)	Returns the remainder of x / y.
LN(x)	Returns the base *e* logarithm of x.

Expression Constraint Functions

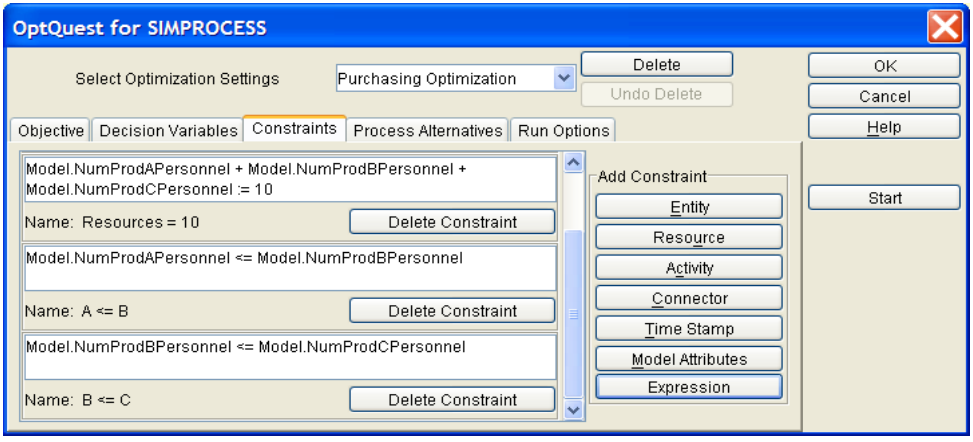
Function	Description
LOG10(x)	Returns the base 10 logarithm of x.
MAXOF(x, y)	Returns the larger of two numbers. (Note: Unlike the SIMPROCESS MAXOF, only two parameters are allowed.)
MINOF(x, y)	Returns the smaller of two numbers. (Note: Unlike the SIMPROCESS MINOF, only two parameters are allowed.)
PI	Mathematical constant pi, approximately equal to 3.14159.
POWER(x, y)	Returns x raised to the y power.
RAND	Returns a random number between 0 and 1 inclusive.
RtoD(x)	Converts radians to degrees.
SIN(x)	Returns the sine of x, where x is an angle in radians.
SINH(x)	Returns the hyperbolic sine of x, where x is an angle in radians.
SQRT(x)	Returns the square root of x.
TAN(x)	Returns the tangent of x, where x is an angle in radians.
TANH(x)	Returns the hyperbolic tangent of x, an angle in radians.

The optimization setup for the Purchasing model is highly constrained. This is because of the three

expression constraints. The first constraint is named **Resources = 10**. This constraint requires that the sum of the decision variables (model parameters) must equal 10. Since these decision variables set the number of units of each resource type, the name **Resources = 10** was assigned. The dialog has a **Validate** button. This button allows validation of the syntax of the expression constraint before selecting **OK**.



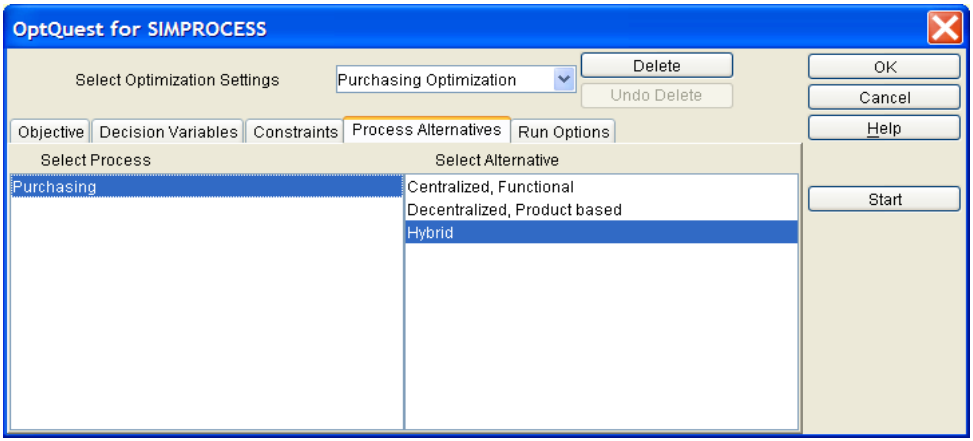
There are two other expression constraints in the Purchasing model, **A <= B** and **B <= C**. These constraints state that the number of units of the resource ProductAPersonnel must be less than or equal to the number of units of the resource ProductBPersonnel, and the number of units of the resource ProductBPersonnel must be less than or equal to the number of units of ProductCPersonnel. Scrolling down on the **Constraints** tab brings all three expression constraints into view.



Expression constraints can be modified from the Constraints tab by clicking in the text area and changing as necessary. However, expression constraint validation is not available. To use validation, the constraint must be deleted and recreated.

Process Alternatives

The **Process Alternatives** tab displays all processes in the model that have more than one alternative. When a process is selected on the left, the alternatives for that process are displayed on the right. This allows the alternative to be selected that will be active for the optimization. If no alternative is selected for a process, the alternative that was active the last time the model was saved will be active for the optimization. In the Purchasing model, the Purchasing process is the only process that has more than one alternative, thus, it is the only process listed on the left. The Purchasing process' three alternatives are listed on the right.

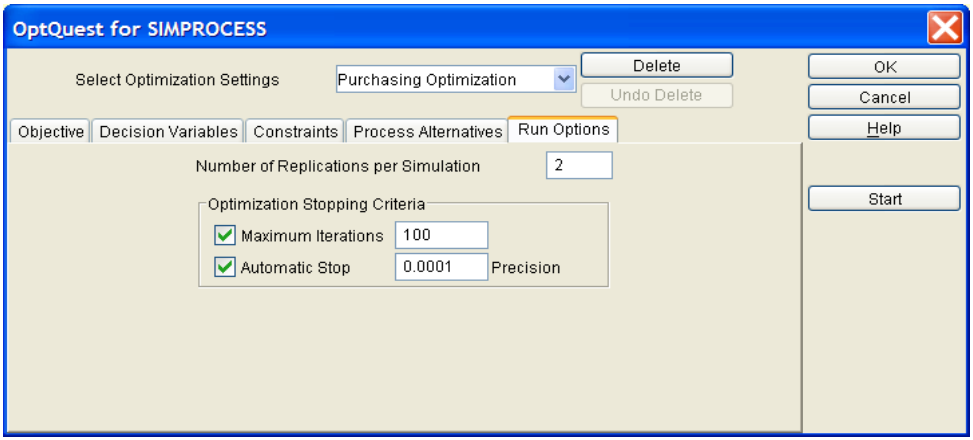


Run Options

The Run Options tab sets the number of replications for each simulation and the optimization stopping criteria. Unless the model is discrete, it is recommended that each simulation be run for more than one replication. The number of replications needed should be determined before setting up the optimization. If no value is entered, each simulation run will run with the number of replications last saved in the model. If a value is entered, that value will be reflected in the **Number of Replications** in the **Run Settings** of the model the next time the model is opened after the optimization. In the Purchasing model, the **Number of Replications per Simulation** is set to 2. This was set to a small number for demonstration purposes only. Only two replications and the tight constraints cause the Purchasing optimization to run quickly.

Apart from user intervention, the length of the optimization is controlled by two options: **Maximum Iterations** and **Automatic Stop**. At least one of the stopping criteria must be selected. Both options can

be selected. If both are selected, the criteria that is satisfied first will stop the optimization. **Maximum Iterations** is the maximum number of iterations OptQuest will attempt before stopping the optimization. The value must be an integer greater than zero. When **Automatic Stop** is selected, the optimization stops when the value of the objective stops improving. **Precision** determines when two objective values are considered equal. The default is 0.0001.

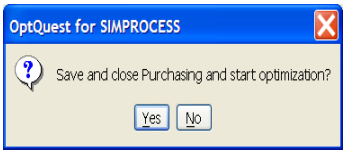


Saving Optimization Settings

Selecting **OK** will close the dialog and add the defined optimization settings to the model. The model must be saved for the optimization settings to persist. Selecting **Start** will close the dialog, add the defined optimization settings to the model, and save the model. Thus, performing another save is not necessary. **Cancel** closes the dialog and discards any changes.

Running an Optimization

To run an optimization, if the optimization settings dialog is not already displayed, select **OptQuest** from the **Tools** menu. Once the optimization settings dialog has appeared, either define an optimization or select a previously defined optimization. Select the **Start** button. At that point a dialog will appear asking for confimation before saving the model and starting the optimization. If **No** is selected, the operation is canceled. If **Yes** is selected, the dialog closes, the model is saved and closed, and the optimization starts.

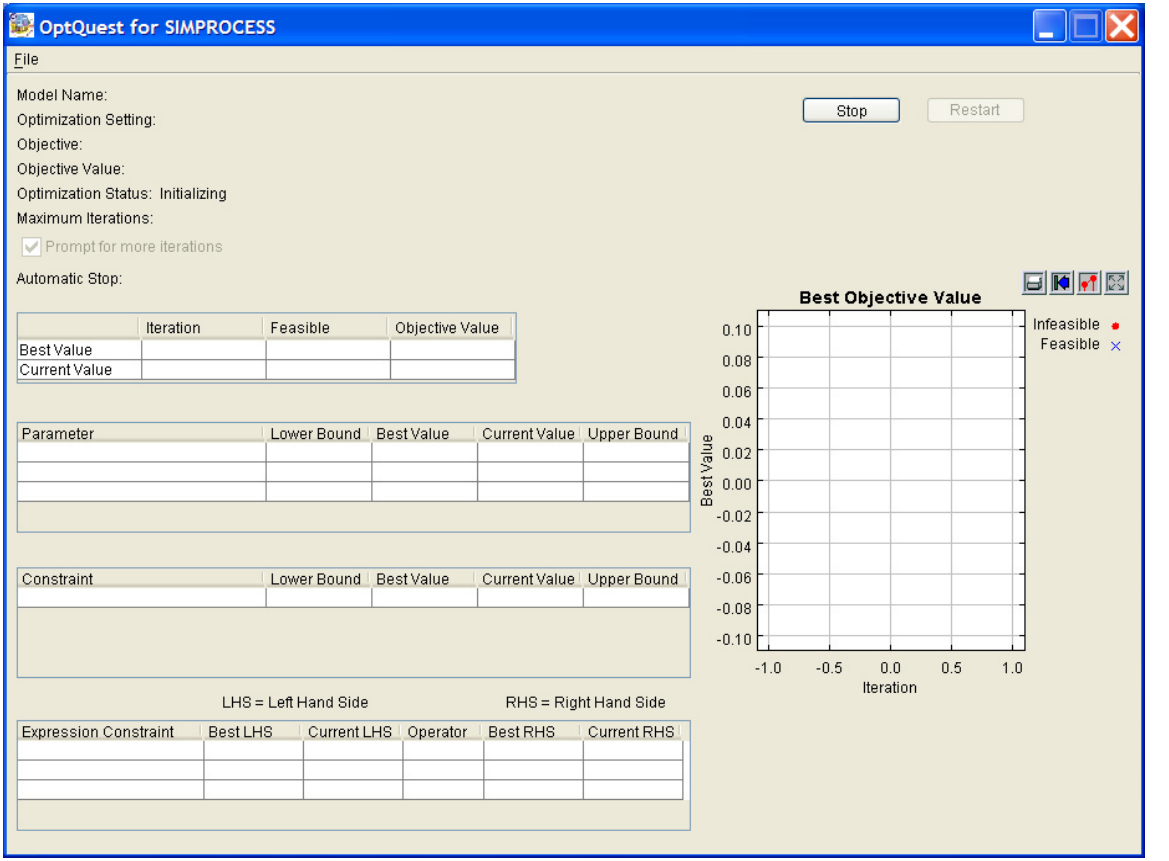


OptQuest for SIMPROCESS Interface

An OptQuest for SIMPROCESS optimization runs in a separate Java Virtual Machine (JVM) and uses a separate interface from SIMPROCESS. Therefore, once an optimization has started, SIMPROCESS can continue to be used without affecting the optimization. This means multiple optimizations can run simultaneously. However, that may not be practical, since running an optimization is very CPU intensive (since it is running a simulation, which monopolizes the CPU), and, depending on the size of the model, memory intensive. Also, it may not be practical to run a simulation with SIMPROCESS while an optimization is running for the same reasons. Running multiple optimizations and/or simulations will often perform better on non-Windows systems.

The OptQuest for SIMPROCESS interface primarily consists of text, tables, and a graph to monitor the optimization. There is a button to stop the optimization, and there are reporting options on the **File** menu once the optimization is complete.

When the interface appears, all status objects are empty except for the **Optimization Status** field, which displays **Initializing**. The tables show the status of the objective value, the decision variables, the performance measure constraints, and the expression constraints. The objective value table and the decision variables table will always appear. The performance measure constraints table and the expression constraints table will only appear if those types of constraints exist. The graph plots the best objective value based on whether or not the best is feasible. The example below is from the Purchasing model.



Status Text

The following status text is displayed:

- **Model Name** - name of the model being optimized
- **Optimization Setting** - the name of the optimization setting selected when the optimization was started
- **Objective** - Minimize or Maximize
- **Objective Value** - the performance measure selected for optimization
- **Optimization Status** - Initializing, Running Iteration n, Complete, Stopping Optimization, User Terminated, or Error
- **Maximum Iterations** - number of iterations or Off
- **Automatic Stop** - On or Off

Optimization Status descriptions:

- **Initializing** - Optimization is in setup stage
- **Running Iteration n** - Optimization is running the *n*th iteration
- **Optimal Solution Found** - Optimization completed normally with no errors
- **Stopping Optimization** - Optimization is in the process of stopping because user selected **Stop** button
- **User Terminated** - Optimization stopped by user
- **Error** - Optimization stopped due to error.

Status Tables

The objective value table lists the **Best Value** and the **Current Value** for the **Iteration**, whether the best and current values are **Feasible**, and the best and current **Objective Value**.

	Iteration	Feasible	Objective Value
Best Value	2	Yes	34375.5887
Current Value	3	No	34202.3246

The decision variables table lists the decision variables (**Parameters**) included in the optimization. The **Lower Bound**, **Best Value**, **Current Value**, and **Upper Bound** are displayed.

Parameter	Lower Bound	Best Value	Current Value	Upper Bound
Model.NumProdAPersonnel	1	2	1	10
Model.NumProdBPersonnel	1	2	1	10
Model.NumProdCPersonnel	1	6	8	10

The performance measure constraints table lists the performance measures identified as constraints for the optimization. The **Lower Bound**, **Best Value**, **Current Value**, and **Upper Bound** are displayed.

Constraint	Lower Bound	Best Value	Current Value	Upper Bound
TotalWait:Value	-infinity	5.7097	57.6889	30.0

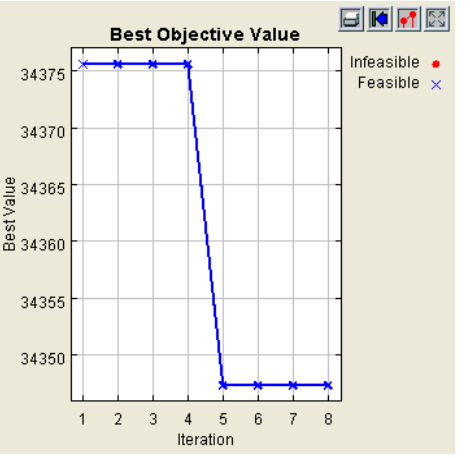
The expression constraint table lists the expression constraints defined for the optimization. The name, not the expression itself, is displayed in the **Expression Constraint** column. The other columns are **Best LHS**, **Current LHS**, **Operator**, **Best RHS**, and **Current RHS**. **LHS** stands for **Left Hand Side**, and **RHS** stands for **Right Hand Side**. These columns show the best and current values for both sides of each expression constraint. The **Operator** column shows the comparison operator between both sides of each expression constraint.

Expression Constraint	Best LHS	Current LHS	Operator	Best RHS	Current RHS
Resources = 10	10.0	10.0	=	10.0	10.0
A <= B	2.0	1.0	<=	2.0	4.0
B <= C	2.0	4.0	<=	6.0	5.0

Objective Graph

The graph of the objective value plots the best objective value for each iteration. Infeasible values are plotted with dots in red, and feasible values are plotted in blue with Xs. In the example below from the Purchasing model, the first three values were infeasible and the remaining feasible. Remember, once the best value is feasible, the best value will not be infeasible again. To zoom in on a portion of the graph, click and drag over the portion of the graph to enlarge. The buttons above the graph do the following:

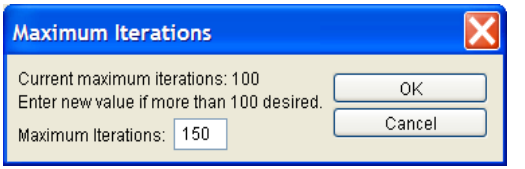
- Print the plot.
- Reset the X and Y ranges to their original (empty plot starting) values.
- Set the plot format.
- Rescale the plot to fit the data. Used after zooming to return to full view of plot.



Maximum Iterations Prompt

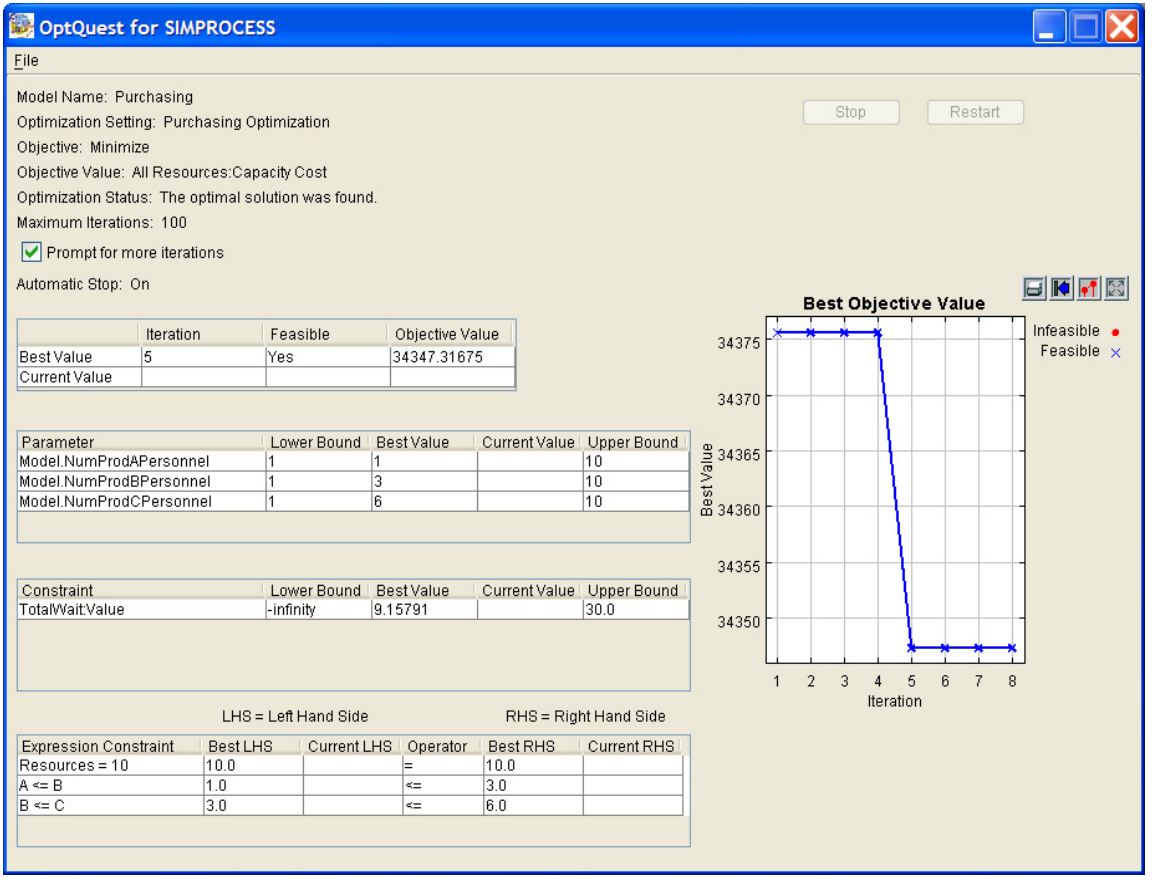
When a maximum number of iterations has been set for the optimization, the checkbox **Prompt for more iterations** is enabled. This checkbox defaults to selected. When selected, the optimization prompts for more iterations at the end of the next to the last iteration. For instance, if the maximum iterations is set to 100, at the end of iteration 99 the optimization will prompt for a new maximum for the iterations. A new maximum must be entered, not the number of additional iterations. So, for this example, the

number entered must be 101 or larger (150 entered). If **Prompt for more iterations** remains selected, the optimization will prompt again when the iteration is one less than the maximum (149 in this example). Deselect this option to have the optimization complete without interruption.

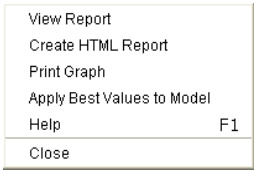


Optimization Solution Options

The OptQuest for SIMPROCESS interface shows the current status of the optimization while it is running. Once the optimization is complete, the interface only shows the best values. The example below is from the Purchasing model.



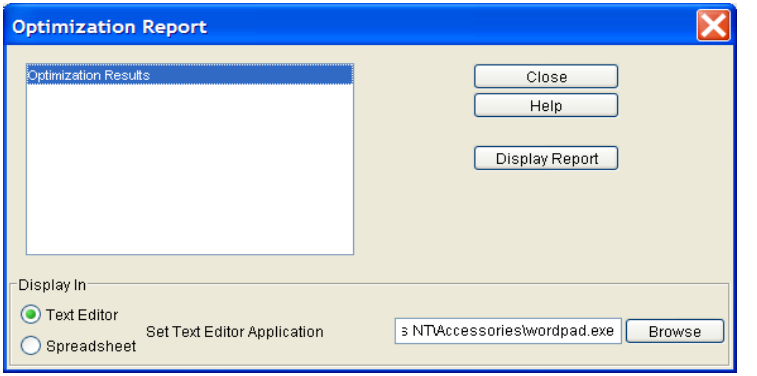
The **File** menu contains other options for examining solutions, and it has an option for applying the best solution to the model. **Help** is also accessed from the **File** menu.



View Report

View Report brings up a dialog similar to the **Standard Report** dialog. With this dialog the report can

be displayed in a text editor or in a spreadsheet.



The report lists the name of the model, the start date/time and end date/time of the optimization, the optimization settings, and the best values for the objective, decision variables, and constraints.

Create HTML Report

This option creates the same report as View Report. However, since it is an HTML file, the objective graph is included as well.

Print Graph

This option sends the objective graph to the selected printer.

Apply Best Values to Model

Apply Best Values to Model assigns the best values from the decision variables to the model parameters in the model. Thus, when the model is reopened in SIMPROCESS, and run is selected, the run values for the model parameters reflect the best values from the optimization. Also, if **OptQuest** is selected again, the starting values for the decision variables are the best values from the optimization.

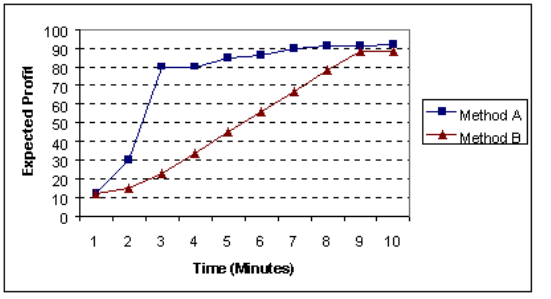
Tips and Suggestions

Search Methodology

There are many factors that influence the performance of OptQuest. For example, consider two optimization methods, A and B, applied to a problem with the objective of maximizing expected returns. When evaluating the performance of each method, consider which method satisfies the following criteria:

- Finds a solution with a larger expected return
- Jumps to the range of high-quality solutions faster

Below is the Performance Graph for the two hypothetical methods.



The figure above shows that, although both methods find solutions with a similar expected profit after 10 minutes of searching, method A jumps to the range of high-quality solutions faster than B. For the criteria listed above, method A performs better than method B.

OptQuest will obtain performance profiles similar to method A. OptQuest's search methodology is very aggressive and attempts to immediately find high-quality solutions, causing large improvements, (with respect to the initial solution), early in the search. This is critical when OptQuest can perform only a limited number of simulations.

However, several factors affect OptQuest's performance, and the importance of these factors varies from one situation to another. This section reviews these factors and offers tips and suggestions on how to achieve maximum performance.

Factors that affect search performance

Any heuristic method for solving problems cannot guarantee that it will find the optimal solution. It

might only find a solution that is close to the optimal solution, usually referred to as the best solution; this is why maximizing performance is critical.

The following is a list of relevant factors that directly affect search performance. Each factor is explained in sections after the list.

- Number of decision variables
- Initial values
- Decision variable bounds
- Complexity of the objective
- Constraints
- Feasibility
- Number of replications and simulations
- Simulation accuracy
- Simulation speed

Number of Decision Variables

The number of decision variables greatly affects OptQuest's performance. OptQuest has no physical limit on the number of decision variables that can be used in any given problem. However, the performance might deteriorate if more than 100 decision variables are used.

Also, as the number of decision variables increases, more simulations are needed to find high-quality solutions. General guidelines for the minimum number of simulations required for a given number of decision variables in a problem are:

Decision Variables	**Minimum number of simulations**
Less than 10	100
Between 10 and 20	500
Between 20 and 50	2,000
Between 50 and 100	5,000

For very large numbers of decision variables, try this procedure:

- Decrease the number of replication per simulation, at least initially
- Run the optimization to get an approximate solution
- Set the suggested values to the approximate solution
- Further restrict the bounds on the decision variables

- Increase the number of replications to increase accuracy
- Rerun the optimization

One option is to de-select certain decision variables and optimize the rest. If an optimization has already been run, there might be information available about which decision variables have the least effect on the objective function. When one or more decision variables is de-selected and the optimization is rerun, the search focuses on the remaining, more important, decision variables.

Initial Values

The initial values are the values listed as the **Starting Values** of the **Decision Variables** tab. Initial values are important because the closer they are to the optimal value, the faster OptQuest can find the optimal solution. If the initial values are constraint-infeasible, they are ignored.

For potentially large models with many decision variables, it might be helpful to first run a simplified version of the optimization to find initial values for the full-blown model. For example, expected values could be used for some of the random variables in the model.

Decision Variable Bounds

OptQuest's performance can be significantly improved by selecting meaningful bounds for the decision variables. Suppose, for example, that the bounds for three decision variables (X, Y, and Z) are:

```
0 <= X <= 100
0 <= Y <= 100
0 <= Z <= 100
```

And in addition to the bounds, there is the following constraint:

```
10*X + 12*Y + 20*Z <= 200
```

Although the optimization model is correct, the decision variables bounds are not meaningful. A better set of bounds for these decision variables would be:

```
0 <= X <= 20
0 <= Y <= 16.667
0 <= Z <= 10
```

These bounds take into consideration the values of the coefficients and the constraint limit to determine the maximum value for each decision variable. The new "tighter" bounds result in a more efficient search for the optimal values of the decision variables. However, this efficiency comes at the expense of missing the optimal solution if it lies outside the specified bounds.

Complexity of the Objective

A complex objective has a highly nonlinear surface with many local minimum and maximum points.

OptQuest is designed to find global solutions for all types of objectives, especially complex objectives. However, for more complex objectives, generally it is required to run more simulations to find high-quality global solutions.

Since only one value can be optimized, complex objectives must be defined within the model expressions. (See "Customizing a Model with Attributes and Expressions" on page 237.)

Constraints

Constraints can be used to restrict the values of decision variables (model parameters) by defining relationships among the decision variables; constraints can also restrict the value of output variables (performance measures).

If a constraint is defined using only decision variables, OptQuest can eliminate sets of decision variables values that are constraint-infeasible before it runs the simulation. Limiting the optimization by defining constraints on decision variables is extremely time-effective.

If a constraint contains a performance measure, a simulation must be run to determine whether the suggested solution satisfies the constraint.

The search process benefits from the use of constraints on decision variables and tight bounds on decision variables. However, performance generally suffers when performance measure constraints are included in the optimization model for two reasons:

- Performance measure constraints are very time-consuming to evaluate, since OptQuest must run an entire simulation before determining whether the results are constraint-infeasible.
- To avoid running constraint-infeasible simulations, OptQuest must identify the characteristics of solutions likely to be constraint-feasible; this makes the search more complex and requires more time.

Even though performance measure constraints can greatly decrease the number of feasible simulations performed during an optimization, performance measure constraints can focus the search to effectively rule out undesirable solutions.

If there are lots of performance measure constraints that OptQuest can't easily satisfy, consider combining the output constraints into one multi-objective function.

Feasibility

OptQuest makes finding a feasible solution its highest priority. Once it finds a feasible solution, it then

concentrates on finding better solutions.

The fact that a particular solution may be infeasible does not imply that the problem itself is infeasible. However, infeasible problems do exist. For example, suppose that in a Job Shop problem a foreman insists on finding an optimal configuration with the following constraints:

```
drills + grinders <= 4
drills + grinders >= 5
```

Clearly, there is no combination that will satisfy both of these constraints.

Or, for this same example, suppose the bounds for a decision variable were:

```
3 <= saws <= 5
```

And a constraint was:

```
saws <= 2
```

This also results in an infeasible problem. OptQuest will display an error message and terminate infeasible optimizations.

Infeasible problems can be made feasible by fixing the inconsistencies of the relationships modeled by the constraints. OptQuest detects optimization models that are constraint-infeasible and reports them.

If a model is constraint-feasible, OptQuest will always find a feasible solution and search for the optimal solution (i.e., the best solution that satisfies all constraints).

Number of Replications and Simulations

When OptQuest runs an optimization, it runs a simulation to evaluate each set of decision variable (model parameter) values. Therefore, the quality of the optimization results depends on the number of simulations (iterations) and the number of replications per simulation.

For a set period of time, the number of replications per simulation is inversely related to the number of simulations; as one increases, the other decreases. Decreasing the number of replications can help increase the number of simulations.

The more simulations OptQuest can run, the more sets of values it can evaluate, and the more likely OptQuest is to find a solution close to the optimal solution.

Simulation Accuracy

There are two factors that affect simulation accuracy:

- Number of replications per simulation

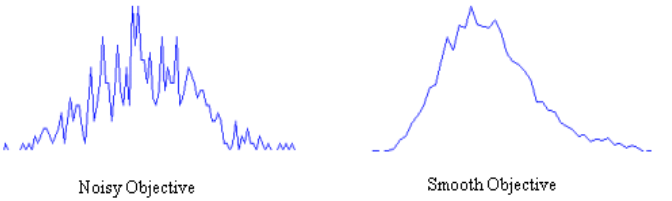
- Noisiness of the objective

Number of replications per simulation

For sufficient accuracy, the number of replications per simulation must be set to the minimum number necessary to obtain a reliable estimate of the objective function being optimized; this minimum number is typically found with empirical testing.

Objective noisiness

Noisiness can also affect the accuracy of OptQuest results.



The objective on the left has significant amounts of noise caused by the probability distributions used to model the problem's uncertainty. For these types of objectives, OptQuest might have trouble discerning the minimum or maximum value. Noisy functions can be detected by watching for best solutions that seem to "bounce around" from one set of values to completely different sets of values. To help solve this problem, increase the number of replications per simulation. On the right, the objective appears smooth due to the relative certainty in the model assumptions. In these cases, OptQuest should quickly converge to the best solution.

Simulation Speed

Some suggestions for increasing speed include:

- Reduce the size of the model (or the time horizon of the simulation).
- Increase the system's RAM memory.
- Reduce the number of uncertain elements in the simulation.
- Close other applications.

OptQuest Demonstration Models

Two of the demonstration models that come with SIMPROCESS have been set up for optimization: the Purchasing model (Purchasing.spm) and the Inventory model (Inventory.spm).

Purchasing Model

This model was used throughout this chapter to describe how to set up and run an OptQuest optimization. Thus, an extended description will not be given here. The model is described in Chapter 5 of the *SIMPROCESS Getting Started Manual*. The optimization set up for this model should not be considered a true optimization scenario. The constraints are very tight, and the number of replications per simulation is only two. This was done so the example would run within a minute or two. The value of this model is in learning how to create decision variables and constraints.

Inventory Model

This model was developed for the purpose of finding optimal values. The model is described in Chapter 5 of the *SIMPROCESS Getting Started Manual*. Briefly, the Inventory model demonstrates an Inventory Pull and Manufacturing system. The process is characterized by the Reorder Points and Reorder Quantities defined for each resource in the supply chain. There are four steps in the supply chain: Warehouse, Assembly, Component1 Vendor and Component2 Vendor, and the Raw Material Vendors. Inventory is pulled only when it is needed (there is insufficient stock to fill the order or the Reorder Point has been reached). There are 10 Model Attributes in the model that have been designated as model parameters.

- Comp1ReOrderPt - Component Vendor 1 (Comp1 resource) Reorder Point
- Comp1ReOrderQty - Component Vendor 1 (Comp1 resource) Reorder Quantity
- Comp2ReOrderPt - Component Vendor 2 (Comp2 resource) Reorder Point
- Comp2ReOrderQty - Component Vendor 2 (Comp2 resource) Reorder Quantity
- FinProdReOrderPt - Finished Product (FinProduct resource) Reorder Point
- FinProdReOrderQty - Finished Product (FinProduct resource) Reorder Quantity
- Raw1ReOrderPt - Raw Material Vendor 1 (Raw1 resource) Reorder Point
- Raw1ReOrderQty - Raw Material Vendor 1 (Raw1 resource) Reorder Quantity
- Raw2ReOrderPt - Raw Material Vendor 2 (Raw2 resource) Reorder Point
- Raw2ReOrderQty - Raw Material Vendor 2 (Raw2 resource) Reorder Quantity

The goal is to minimize the amount of inventory held without impacting the customer negatively (increase order cycle time). This can be done by finding the optimal Reorder Points and Quantities

for each node in the supply chain. Using OptQuest the optimal Reorder Points and Reorder Quantities can be found. Thus, the decision variables for the optimization are the model parameters, and the default values for the attributes are the **Starting Values** for the decision variables. (See "Decision Variables" on page 407.)

The objective is twofold: minimize inventory (FinProduct resource) and minimize the amount of time it takes to fill a customer order. See "Preparing for Optimization," beginning on page 404 for a discussion on how these dual objectives are combined into one objective.

The performance measure for the amount of inventory and the performance measure for the amount of time it takes to fill a customer order are used as performance measure constraints. These values are obtained using the `GetResourceStatistic` and `GetEntityStatistic` expression statements in the **End Simulation** expression for the model (**Define/Model Expressions**). These values are assigned to Model Attributes, which are used as constraints.

The number of replications per simulation is set to 1, the maximum number of iterations is 150, and the automatic stop feature is turned on with a precision of 0.1. Note that the number of replications is set to 1 to reduce the time required to run the optimization. In normal usage, the number of replications would be greater than one.

This optimization takes from 20 minutes to a few hours to run, depending on system memory and processor speed.

CHAPTER 16

SIMPROCESS Dashboards

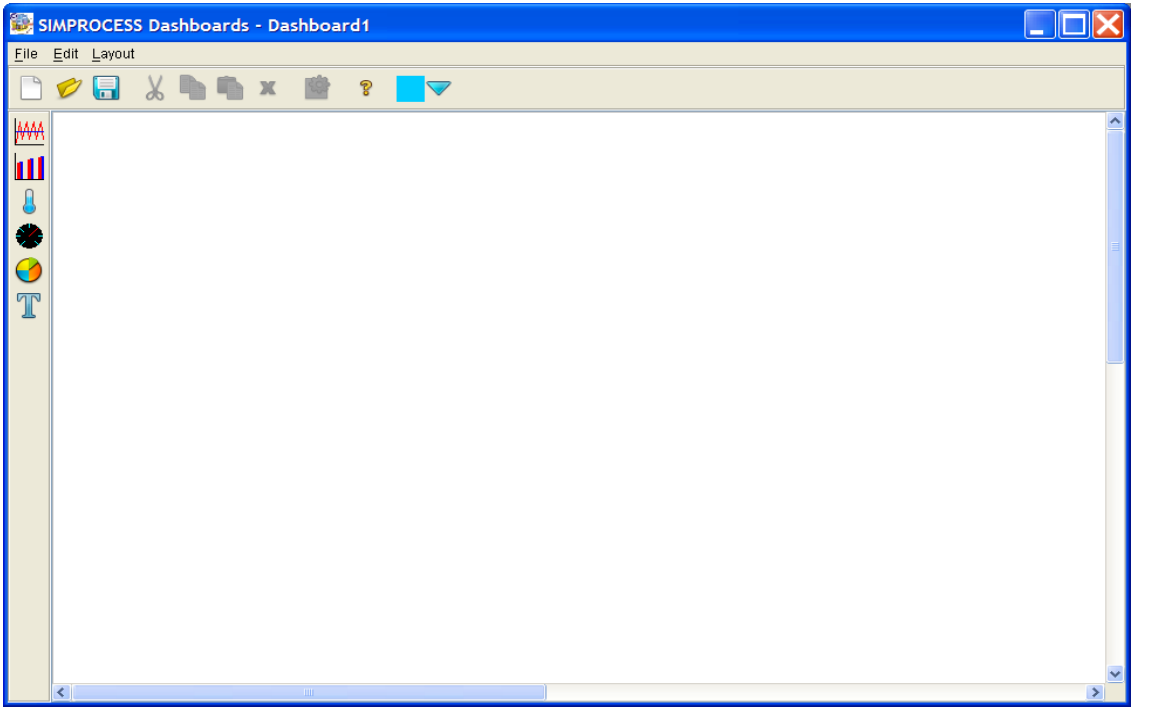
SIMPROCESS Dashboards are collections of dynamic graphs that can be displayed locally or remotely by a Dashboard Server. The graphs contained by Dashboards can be of the same type or of differing types.

Dashboards are defined independent of SIMPROCESS models. Thus, a Dashboard can be used with multiple models, or multiple models may use a single Dashboard. To use a Dashboard with a model, the Dashboard must be Assigned to a model. The Assign process links the Dashboard to the model, indicates the location of the Dashboard Server for display (host or IP address and port), and sets the values that will be displayed on the graphs defined for that Dashboard.

During a simulation, Dashboards can only be displayed by using a Dashboard Server. A copy of the Dashboard file must be located with the Dashboard Server.

Defining Dashboards

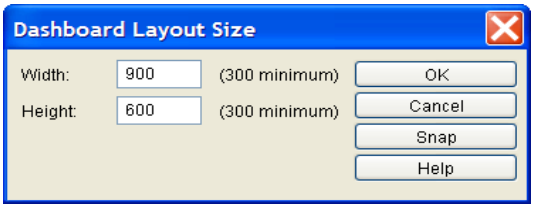
Dashboards are defined independent of SIMPROCESS models. Thus, no model needs to be open to define a Dashboard. The **Report** menu contains a **Dashboard** item with a submenu that has two items: **Define...** and **Assign...**. Selecting **Define...** brings up the SIMPROCESS Dashboard graphical user interface (GUI).



The Dashboard GUI is similar to the SIMPROCESS GUI. The primary differences are that only one Dashboard can be open at a time, and the Dashboard GUI initially opens with an empty Dashboard named **Dashboard1**.

Dashboard Layout

The Dashboard layout is similar to the layout of a SIMPROCESS model in that its size can be set (**Layout/Size** menu item), and its background color can be set (**Layout/Background Color** menu item). Selecting **Layout/Size** brings up the following dialog.



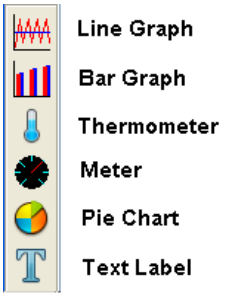
Each Dashboard has a size denoted by a gray line in the editor window. This size, measured in pixels, will be used by the Dashboard Server to build a window in which to display the Dashboard and its Graphs. The width and height values must be at least 300 pixels each but are otherwise unlimited in size. However, when determining the size, consideration should be given to the size of the display on which the server will run when a Dashboard is displayed. The **Snap** button will automatically adjust the width and height values to the smallest values required to contain all Graphs currently in the Dashboard. **Snap** will not resize the layout to smaller than 300 x 300 pixels.

Selecting **Layout/Background Color** sets the color of the layout to the color displayed on the color button on the System Toolbar. The arrow to the right of the color button brings up a color chooser to select the desired color.

Dashboard Graphs

The Graph Toolbar on the left contains the graph types that can be added to the layout. The types of graphs that can be displayed on a Dashboard are

- Line Graph
- Bar Graph (Horizontal or Vertical, 2D or 3D)
- Meter
- Thermometer
- Pie Chart (2D or 3D)
- Text Label



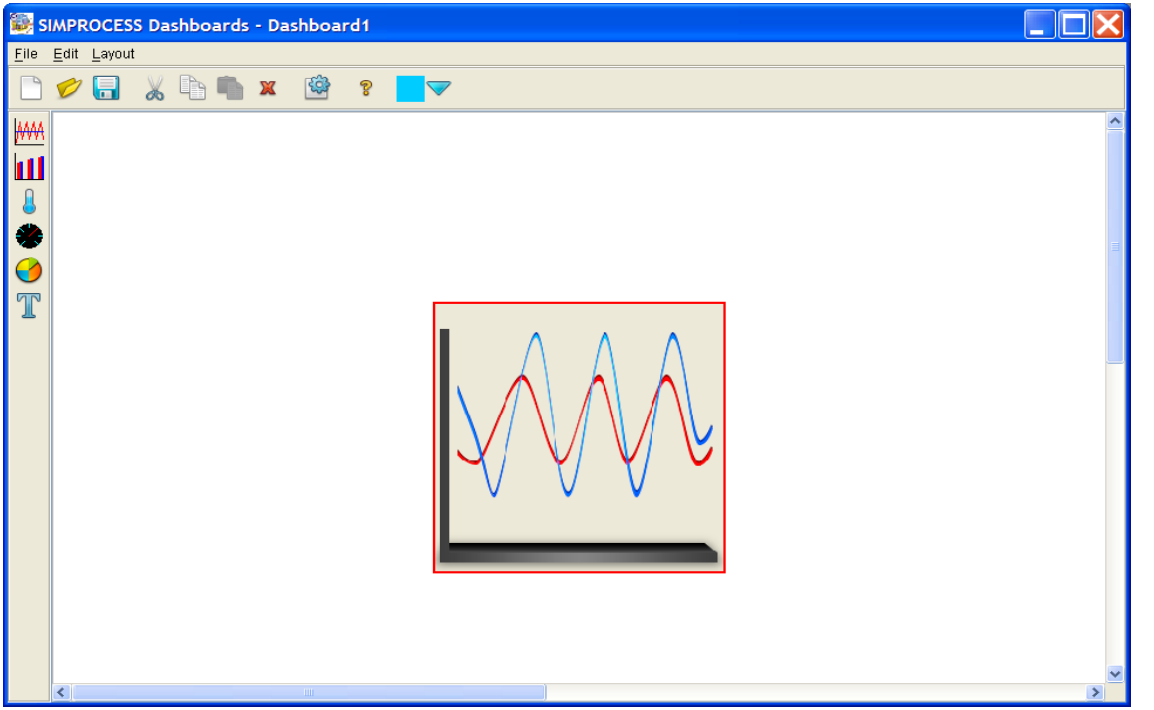
The Line Graph displays one or more X-Y series where the X axis represents simulation time. The Bar Graph displays one or more values. The Thermometer and Meter display one value each. The Pie Chart displays two or more values. The Text Label can be static, or it can display one value dynamically.

Note that the values to be displayed are not assigned while defining Dashboards. The properties that can be set while defining are appearance and

location related properties. The properties set while defining a Dashboard are considered to be the default properties of the Dashboard. Most appearance properties (not location) can be changed when using a Dashboard with a model.

Adding a Graph

Selecting a graph on the Graph Toolbar causes a new panel that represents a graph of that type to appear in the center of the layout. The graph itself does not appear on the layout. Once on the layout, the graph panel can be moved and resized. Also, actual properties of the graph represented by the graph panel can be set. The new graph panel is automatically selected. A graph that is selected has a red border around it. Multiple graphs can be selected by holding down the Control key when clicking on graph panels. Multiple graph panels can also be selected by clicking and dragging a selection rectangle around the desired panels.



Moving a Graph

To move a graph, click on the graph panel and drag while holding down the mouse button. Multiple graph panels can be moved simultaneously by selecting multiple graphs before moving. The same type grid that is available for creating SIMPROCESS models is available for Dashboards on the **Layout**

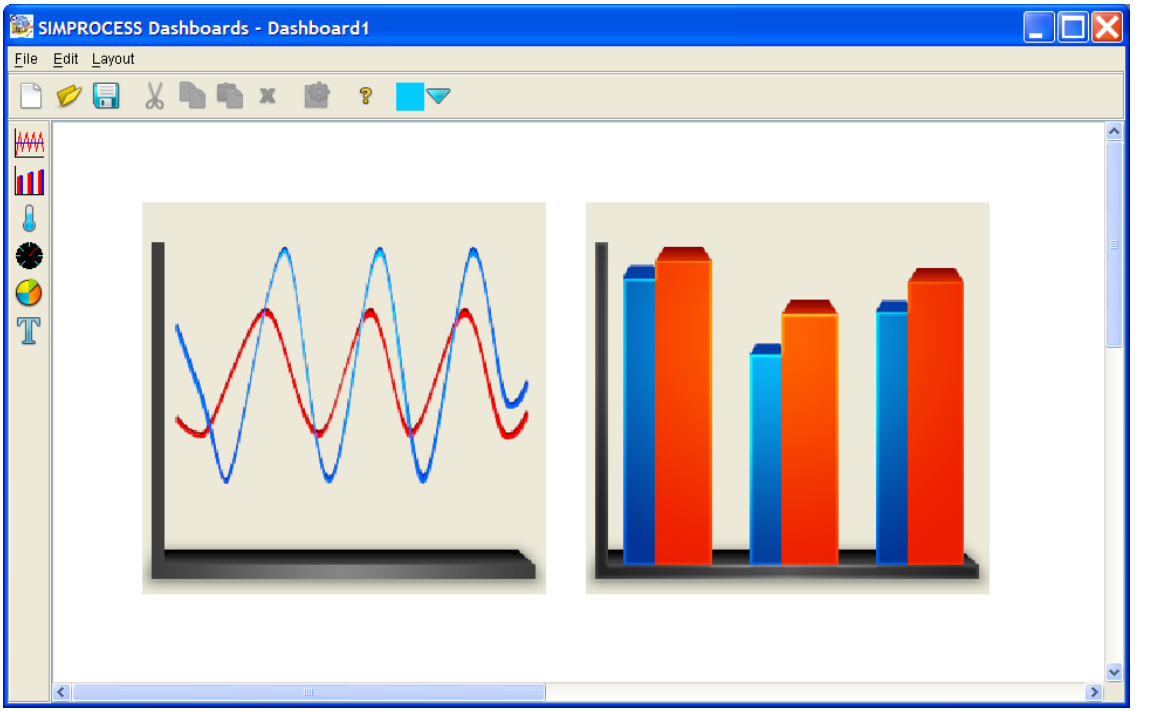
menu. However, due to the size of the graph panels, movement can be difficult with the grid turned on.

Resizing a Graph

The default size of a graph panel (other than Text Label, which is 250 x 100 pixels) is 250 x 250 pixels. A graph panel can be resized by clicking on the edge of a graph panel and dragging. Also, a specific size can be set by selecting **Edit/Resize** from the menu or by right mouse clicking on the graph panel and choosing **Edit/Resize**. Multiple graph panels can be resized simultaneously by selecting multiple graphs before resizing.

Aligning and Distributing Graphs

When two or more graph panels are selected, they can be aligned using the **Layout/Align** menu item or by right clicking on a selected graph panel and choosing the appropriate align item. When three or more graph panels are selected, they can be distributed horizontally, vertically, or circularly using the **Layout/Distribute** menu item or by right clicking on a selected graph panel and choosing the appropriate distribute item. The image below shows a Dashboard with a Line Graph and a Bar Graph that have been moved from the center, resized to 350 x 350 pixels, and aligned.



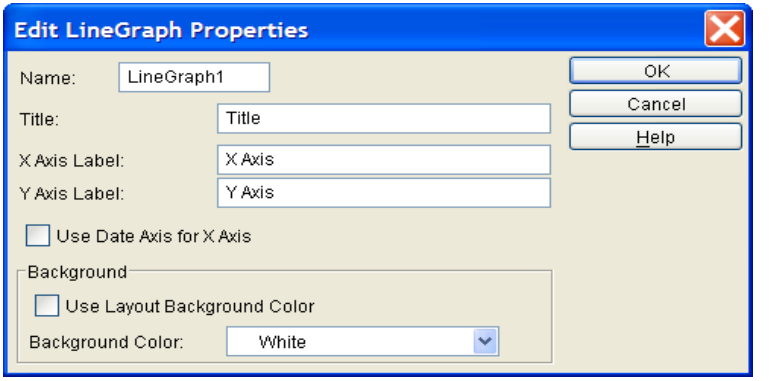
Editing Graph Properties

The default properties for graphs can be edited by double clicking a graph panel, selecting a panel and choosing **Edit/Properties** from the menu, selecting a panel and clicking the properties button on the System Toolbar, or by right clicking and choosing **Properties**. Properties common to all graphs are **Name** and **Background**. The **Name** is used to identify the graph to the Dashboard and must be unique. **Background** sets the color of the background of the graph. A specific color can be selected from the **Background Color** list, or **Use Layout Background Color** can be selected. **Use Layout Background Color** sets the background color of the graph to background color of the layout. Note that **Name** and **Background** cannot be changed when a Dashboard is assigned to a model.

Line Graph Properties

Title, **X Axis**, **Y Axis**, and **Use Date Axis for X Axis** are additional properties for the Line Graph. These default properties can be overridden when the Dashboard is assigned to a model.

- **Title** - default title for the Line Graph
- **X Axis** - label for the x axis
- **Y Axis** - label for the y axis
- **Use Date Axis for X Axis** - if selected, the x axis displays times and dates instead of a number

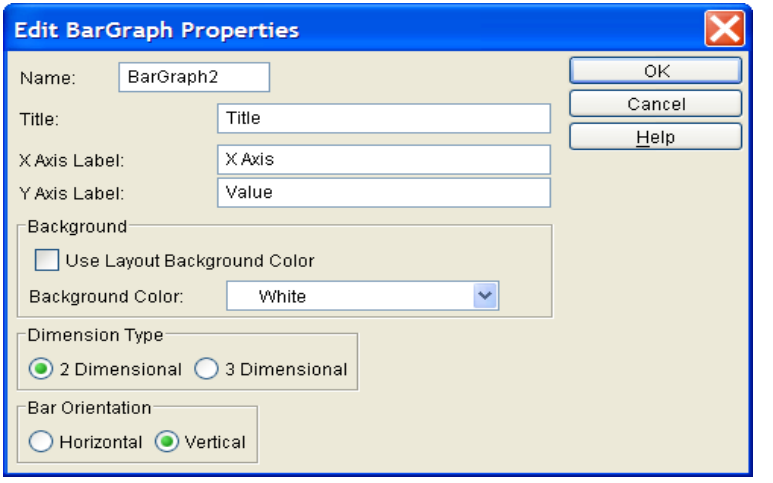


Bar Graph Properties

Title, **X Axis**, **Y Axis**, **Dimension Type**, and **Bar Orientation** are additional properties for the Bar Graph. These default properties can be overridden when the Dashboard is assigned to a model.

- **Title** - default title for the Bar Graph
- **X Axis** - label for the x axis
- **Y Axis** - label for the y axis
- **Dimension Type** - **2 Dimensional** or **3 Dimensional**

- **Bar Orientation** - **Horizontal** or **Vertical**

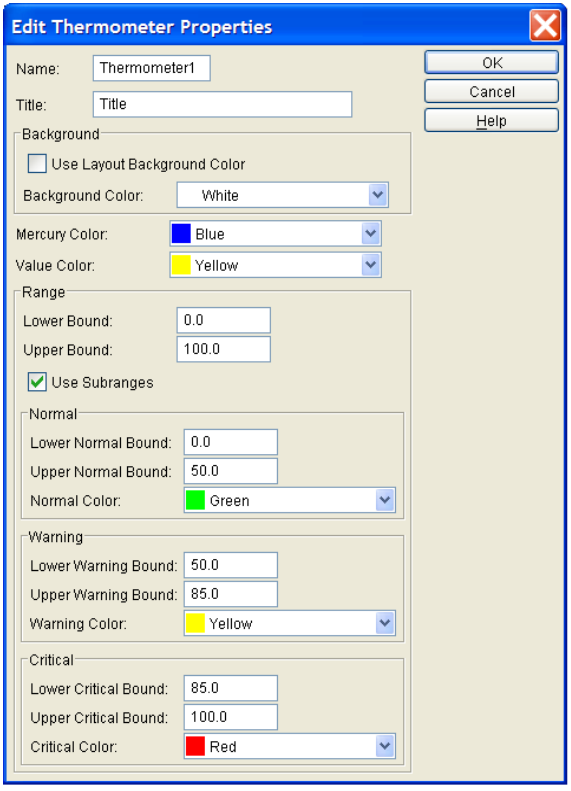


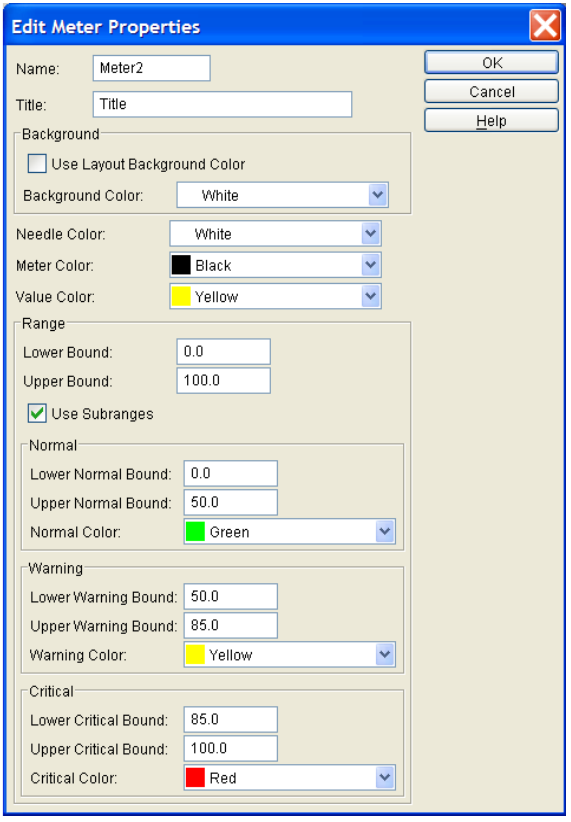
Meter and Thermometer Properties

The Meter and Thermometer have similar properties. Both have a **Title**, a **Range** with optional subranges, and a **Value Color**. The differences are in the other color options. The Meter has a **Needle Color** and a **Meter Color** option. The Thermometer has a **Mercury Color** option.

- **Title** - default title for the Meter or Thermometer
- **Mercury Color** - default color for the mercury in the Thermometer
- **Needle Color** - default color for the needle on the Meter
- **Meter Color** - default color for the Meter
- **Value Color** - default color for the current value of the Meter or Thermometer
- **Lower Bound** - default lower bound for the Meter or Thermometer
- **Upper Bound** - default upper bound for the Meter or Thermometer
- **Use Subranges** - if selected, lower bounds, upper bounds, and colors for three subranges (**Normal**, **Warning**, and **Critical**) can be set. If subranges are used for the Thermometer, the colors selected for the subranges override the **Mercury Color** setting.
- **Lower Normal Bound** - default lower bound for the **Normal** subrange
- **Upper Normal Bound** - default upper bound for the **Normal** subrange
- **Normal Color** - default color for the **Normal** subrange
- **Lower Warning Bound** - default lower bound for the **Warning** subrange
- **Upper Warning Bound** - default upper bound for the **Warning** subrange
- **Warning Color** - default color for the **Warning** subrange

- **Lower Critical Bound** - default lower bound for the **Critical** subrange
- **Upper Critical Bound** - default upper bound for the **Critical** subrange
- **Critical Color** - default color for the **Critical** subrange

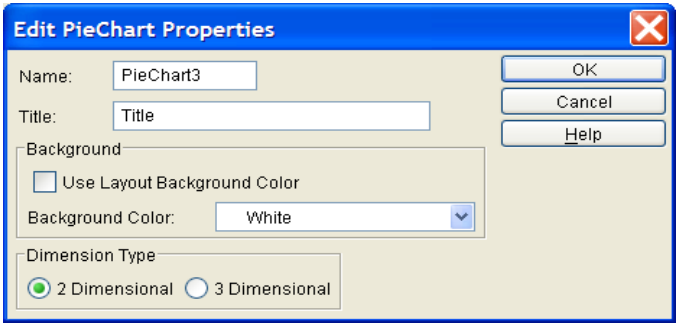




Pie Chart Properties

Title and **Dimension Type** are additional properties for the Pie Chart. These default properties can be overridden when the Dashboard is assigned to a model.

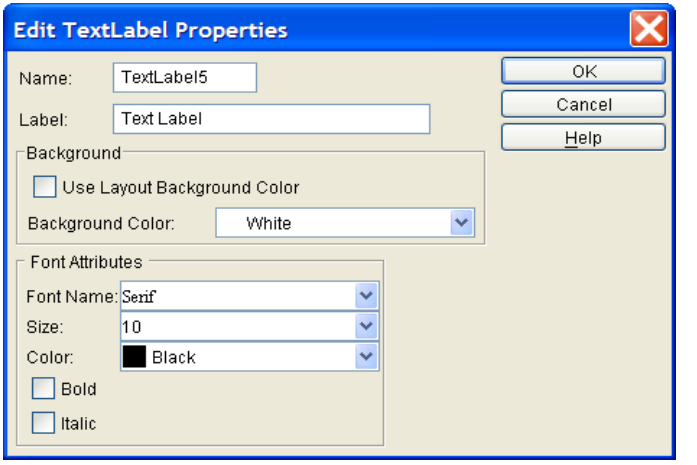
- **Title** - default title for the Pie Chart
- **Dimension Type** - **2 Dimensional** or **3 Dimensional**



Text Label Properties

Text Label properties include **Label** and **Font Attributes,** which include **Font Name**, **Size**, **Color**, **Bold**, and **Italic**.

- **Label** - default text that is displayed
- **Font Name** - default font for label
- **Size** - default font size for label
- **Color** - default font color for label
- **Bold** - default selection for bold
- **Italic** - default selection for italic



Dashboard Menus

File Menu

New places a new Dashboard in the work area displayed in the window. If the current Dashboard has been changed, SIMPROCESS will prompt to save its contents to a file before clearing it in favor of a new Dashboard in the work area.

Open prompts for the selection of a Dashboard file (having the extension ".spd"), which will be read and displayed in the work area. If the current Dashboard has been changed, SIMPROCESS will prompt to save its contents to a file before clearing it in favor of a new Dashboard created from the selected file.

Save saves the current work area into its Dashboard file. If no file has yet been associated with it, this behaves the same as **Save As**.

Save As saves the current Dashboard to a new file. If an existing file is selected, SIMPROCESS will question whether to overwrite that file.

Preview will be enabled when the Dashboard in the work area contains one or more Graphs. It will open a separate window with the specified layout size (**Layout/Size**) containing actual sample graphs configured with the properties set in each graph panel. This is how the actual Dashboard will look when shown by a Dashboard Server.

Close closes the SIMPROCESS Dashboards window. If the current Dashboard has been changed, SIMPROCESS will prompt to save those changes.

Edit Menu

Cut is enabled only if one or more Graphs are selected (as indicated by a red border). **Cut** removes the selected Graphs from the layout and places them onto the clipboard, where they may later be pasted back into the current or a different Dashboard.

Copy is enabled only if one or more Graphs are selected (as indicated by a red border). **Copy** places a copy of the selected Graphs onto the clipboard, where they may later be pasted back into the current or a different Dashboard.

Paste is enabled only if one or more Graphs has been placed (via **Cut** or **Copy**) onto the clipboard. **Paste** places Graphs from the clipboard onto the layout. The clipboard's contents remain intact until changed by a subsequent **Cut** or **Copy** action.

Duplicate is enabled only if one or more Graphs are selected (as indicated by a red border). **Duplicate** acts as though **Copy** was selected followed by **Paste**. That is, it copies all selected Graphs onto the clipboard and then immediately pastes them back into the current layout.

Clear is enabled only if one or more Graphs are selected (as indicated by a red border). **Clear** removes

the selected Graphs from the layout and does not place them onto the clipboard.

Select All is enabled only if one or more Graphs appear on the layout. Select All selects all Graphs on the layout and displays red borders to indicate their selected status.

Resize is enabled only if one or more Graphs are selected (as indicated by a red border). **Resize** presents a Resize dialog where the width and height of the selected Graphs are specified in pixels. If more than one Graph is selected, the size entered will be applied to all of them. Individual Graphs may also be resized by selecting them and moving the mouse cursor over a portion of the border, then dragging when the cursor changes to indicate the direction of the resizing operation.

Properties is enabled only if one or more Graphs are selected (as indicated by a red border). **Properties** presents a Graph Properties dialog for each selected Graph in turn. Properties can also be edited by double-clicking any Graph, clicking the properties button on the System Toolbar, or right clicking and choosing **Properties**.

Layout Menu

Size is always enabled since a Dashboard is considered to be open in the work area at all times. **Size** displays the Dashboard Layout Size dialog.

Background Color is always enabled since a Dashboard is considered to be open in the work area at all times. **Background Color** sets the background color of the Dashboard layout to the currently selected color on the Dashboard Color button on the System Toolbar.

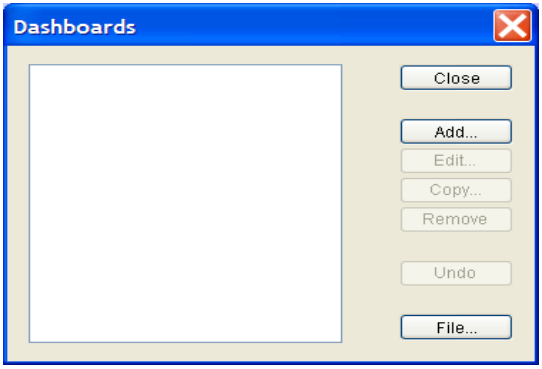
Align is enabled only if two or more Graphs are selected (as indicated by a red border). **Align** presents a dialog with **Top**, **Bottom**, **Left**, **Right**, **Center (Vertical)** and **Center (Horizontal)**. Selected Graphs will be repositioned so that they align as directed. Alignment can also be set by right clicking on a selected Graph.

Distribute is enabled only if three or more Graphs are selected (as indicated by a red border). **Distribute** presents a dialog with **Vertically**, **Horizontally** and **Circular**. Selected Graphs will be repositioned so that they are distributed within the available space (the layout size) as directed, much like the equivalent function in the SIMPROCESS model editor. Selected Graphs can also be distributed by right clicking on a selected Graph.

Snap to Grid, **Grid Lines**, **Grid Spacing**, and **Grid Color** work like their counterparts in the SIMPROCESS model editor. They allow the optional use of grid lines to help in placement of Graphs in a Dashboard. However, due to the size of graph panels, movement is difficult with grid lines turned on.

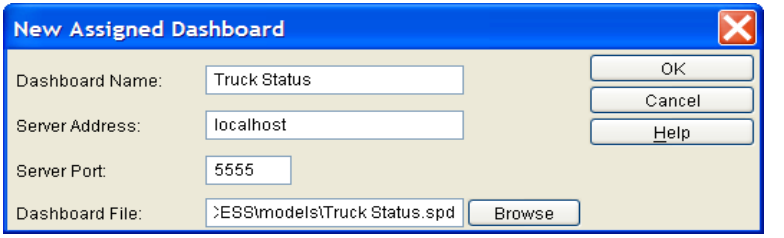
Assigning Dashboards

To assign a Dashboard to a model, select **Dashboard/Assign...** from the **Report** menu. For the **Assign...** menu item to be active, a SIMPROCESS model must be open, and the Dashboard GUI must be closed. **Assign...** brings up a list of the Dashboards assigned to the model. Use the **File...** button to update the Dashboard file's location if the Dashboard was developed on a different system or moved to a location other than where it was located when originally assigned.



Adding a Dashboard Assignment

Dashboards are assigned to a model by using the **Add...** button on the Dashboard list dialog. The New Assigned Dashboard Dialog has four fields: **Dashboard Name**, **Server Address**, **Server Port**, and **Dashboard File**. The **Dashboard Name** defaults to "Dashboard" plus an internally assigned number. This name can be changed to something more meaningful. The **Server Address** defaults to localhost (which refers to the same machine on which SIMPROCESS is running), and **Server Port** defaults to 5555. If not using localhost for the **Server Address**, the **Server Address** must be a fully qualified server name or an Internet Protocol (IP) address. Use the **Browse** button to locate the **Dashboard File** that is to be displayed. (**TIP:** Whenever practical, the file should be in the same directory with the SIMPROCESS model, or in a directory below the one where the SIMPROCESS model resides. This allows the stored reference to be relative, so that moving both the SIMPROCESS model and the Dashboard file to a new location where their relative positions are unchanged will still maintain a correct reference.) Note that **Add...** does not complete the assignment of a Dashboard to a model. The Graphs must be edited as described below to customize the way they appear and plot values to them.

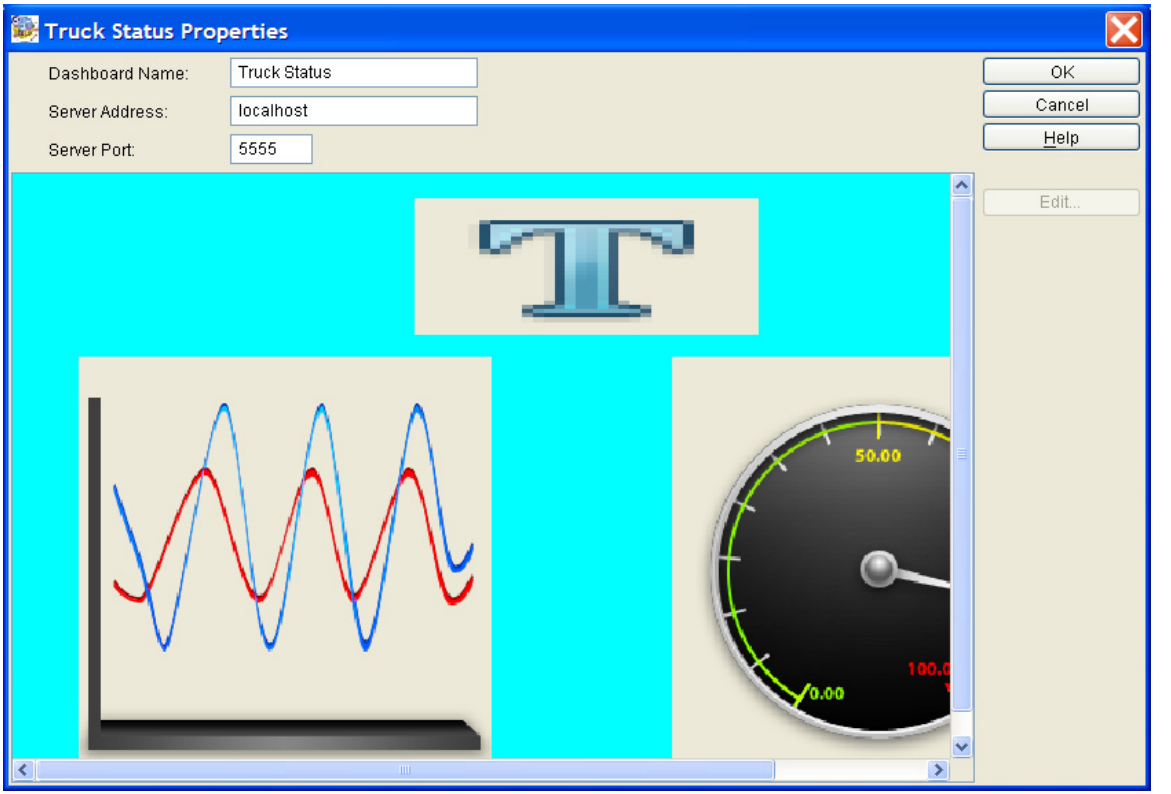


Editing and Removing a Dashboard Assignment

Selecting a Dashboard assignment in the list causes the **Edit** and **Remove** buttons to activate.

Remove removes the Dashboard assignment from the model. A Dashboard assignment that has been removed can be restored with the **Undo** button. **Edit** displays a Dashboard Edit dialog that allows customization of the Dashboard for the model and assignment of plot values to any of the graphs on the Dashboard. The **File** button presents a dialog that allows selecting the Dashboard file for the selected Dashboard assignment and should normally only be needed if its location has changed.

The properties dialog contains three fields that can be edited: **Dashboard Name**, **Server Address**, and **Server Port**. Below those fields is a view of the Dashboard that was assigned to the model. The example below contains a Text Label, Line Graph, and Meter.

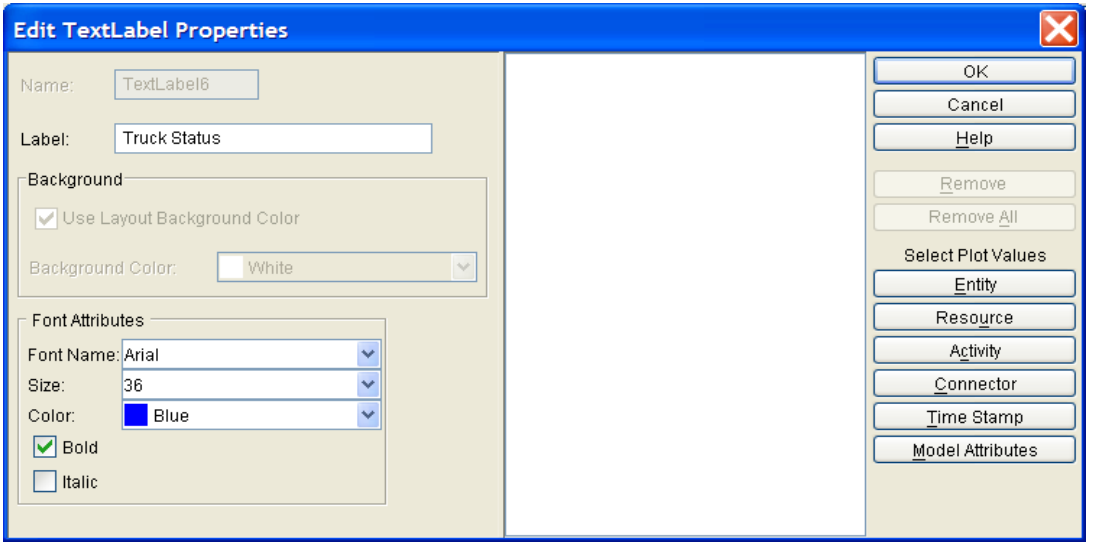


Selecting a Graph causes the **Edit** button to activate. **Edit** displays a dialog with the default properties of the Graph. The Graph properties can also be accessed by double clicking the Graph. These properties (other than **Name** and **Background**) can be customized for the model. Also, the values to be plotted are added to the Graph.

Customizing Properties

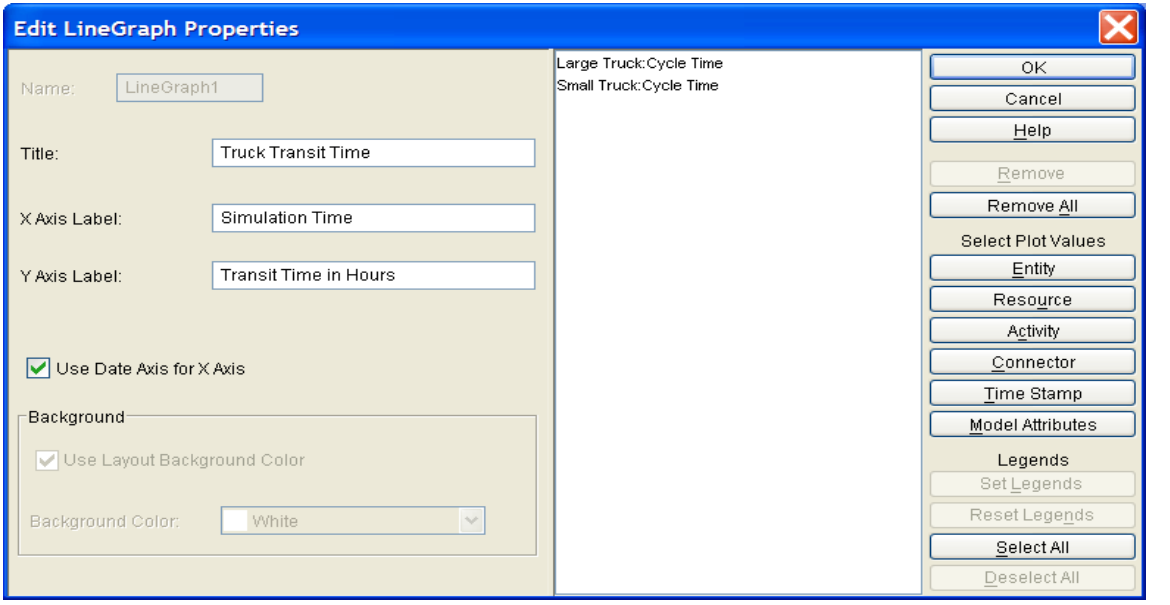
Editing the Text Label brings up the dialog below. The left side of the dialog contains the same properties that are editable when defining Dashboards. Note that **Name** and **Background** cannot be changed. Any changes made in this dialog will override the default properties in the Dashboard file when the Dashboard is displayed. The properties of the other Graphs are customized in the same manner. The right side of the dialog contains the value to display. Since the right side is empty, this Text Label is a static label. Although Text Labels can display one value dynamically, they are best used as static labels. (**Important Note:** If you are planning to have multiple models referring to the same Dashboard while it is displayed, you can prevent any Graphs your model does not use from receiving an initialization message at simulation time which could change their appearance at the

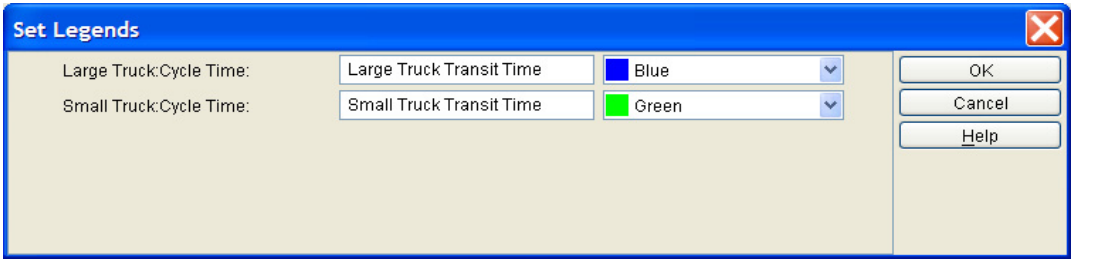
Dashboard Server. For a Text Label, make sure the **Label** value is empty and do not select any plot values. For all other Graphs, do not select any plot values.) Adding values to Graphs is discussed below.



Adding Values to a Graph

Values are added to a graph using the buttons under the **Select Plot Values** heading (**Entity**, **Resource**, **Activity**, **Connector**, **Time Stamp**, and **Model Attribute**). The procedure for adding values is the same as for Custom Plots. See "Adding Values To Custom Plot," beginning on page 209 for detailed instructions on adding values. The Line Graph, Bar Graph, and Pie Chart can plot multiple values. The Meter, Thermometer, and Text Label can only plot one value. The Line Graph, Bar Graph, and Pie Chart also allow the text and color of the legend to be set. The Thermometer allows the text of the legend to be set, but not the color. This is because the color is set in the Thermometer properties. The procedure for setting legends is the same as for Custom Plots. See "Setting Legends," beginning on page 218 for detailed instructions on setting legends. The images below show the properties of the Line Graph with the legend setting below that.

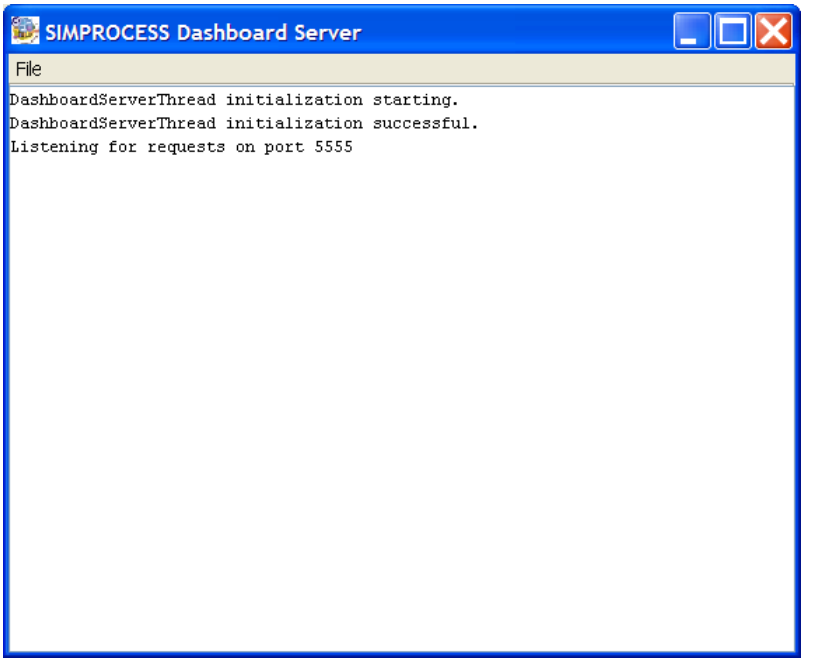

Edit LineGraph Properties
Name:
LineGraph1
Title:
Truck Transit Time
X Axis Label:
Simulation Time
Y Axis Label:
Transit Time in Hours
Use Date Axis for X Axis
Background
Use Layout Background Color
Background Color:
White
Large Truck:Cycle Time
Small Truck:Cycle Time
OK
Cancel
Help
Remove
Remove All
Select Plot Values
Entity
Resource
Activity
Connector
Time Stamp
Model Attributes
Legends
Set Legends
Reset Legends
Select All
Deselect All


Set Legends
Large Truck:Cycle Time:
Large Truck Transit Time
Blue
Small Truck:Cycle Time:
Small Truck Transit Time
Green
OK
Cancel
Help

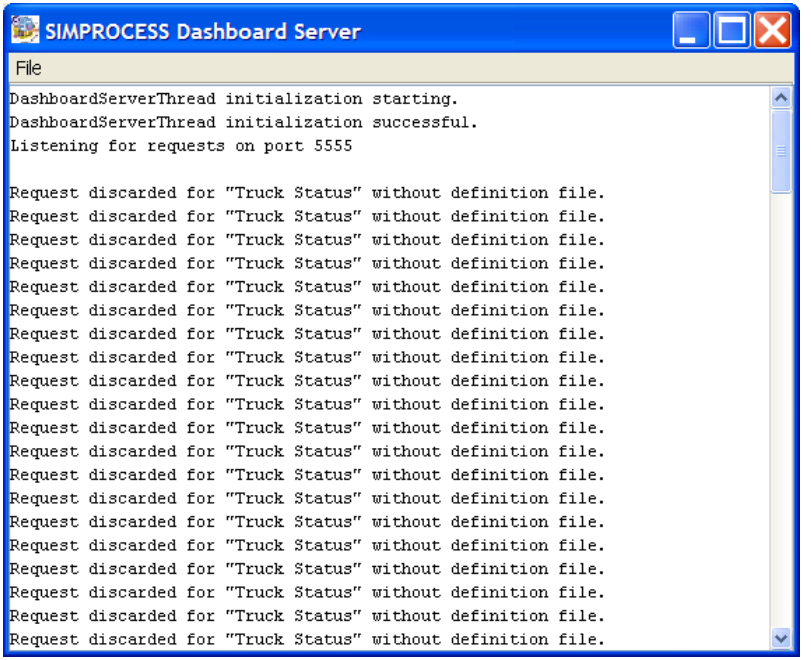
Displaying Dashboards

Dashboards are displayed by a Dashboard Server. A directory named `dashboardserver` is located in the SIMPROCESS directory. A copy of the contents of this directory must be located on each system that is to run a Dashboard Server. Within the `dashboardserver` directory is a directory named `dashboards`. A copy of the Dashboard files (`.spd` files) assigned to the model must be placed in the `dashboards` directory used by a Dashboard Server for it to be displayed. To use a directory other than `dashboards`, modify the `server.properties` file to reference the alternate directory. The port for the Dashboard Server can also be changed in this file. Multiple Dashboard Servers on the same system can use the same `dashboards` directory, but they must have different ports. **Note:** There is one exception to this last item. Multiple Dashboard Servers on one system may listen on the same port if subscribing to multicast groups, even if all subscribe to the same one.

If there are multiple Dashboard assignments in the model with different server addresses and/or ports, a Dashboard Server must be started on each **Server Address** and **Server Port** referenced (or subscribe to the multicast group). If the **Server Address** for any assigned Dashboards is `localhost`, a Dashboard Server can be started from SIMPROCESS by selecting **Tools/Remote/Start Local Dashboard Server**. On Windows, the `server.bat` file can be used to start a Dashboard Server. The `server.sh` file is for Linux systems, though it will also work on other Unix systems. Note that these files specify a path to the JRE installed with SIMPROCESS. If the system does not have a version 1.5 or later JRE, the JRE installed with SIMPROCESS (in the `jre` directory) can be copied if it has the same or a compatible operating system, or a JRE can be downloaded from java.sun.com for most platforms, or from the appropriate vendor for others. The Dashboard Server must be initialized before the simulation begins. When started, the Dashboard Server window appears.



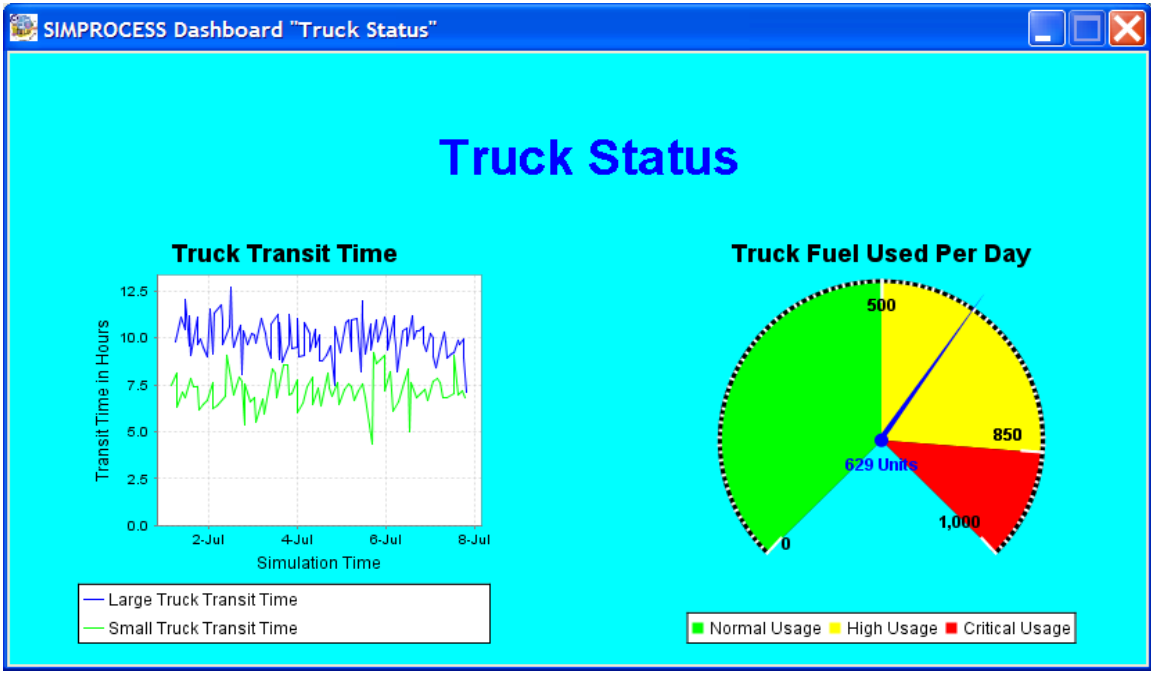
When the simulation is started, the Dashboards assigned to the model will initialize if there are any plot values assigned to any Graphs (for a Text Label, it must also have a **Label** value as noted above). Note that the Dashboard Server window may need to be the active (i.e., frontmost) window for the Dashboard windows to appear if running on the same Windows system as SIMPROCESS. If the Dashboard files referenced by the model are not located in the `dashboards` directory on the server, no Dashboard window will appear, and error messages will be displayed in the Dashboard Server window.



Note that it is possible for messages to not be received by the Dashboard Server, or to be received out of order. To minimize this risk (and improve performance), it is suggested that Dashboards not display a large (more than 10) number of values on a large number of Graphs (more than 4). For example, one Line Graph can plot multiple values (no limit as far as the Line Graph is concerned). However, this means that messages for 10 different values must be received by the Dashboard Server. Alternatively, there could be 10 Meters which each take one value. Again, 10 different values must be received by the Dashboard, and the Dashboard must update 10 different Graphs. If possible, keep the number of values to 10 or less on 4 or less Graphs. Also, it is suggested that the simulation be run with the animation turned on. This slows down the simulation. Simulations that are run with the animation off run extremely fast, so that messages sent to Dashboards could very well arrive faster than the Dashboard Server can handle them (resulting in packet losses). It's usually not necessary to turn on entity movement (although that helps). Turning on Activity Counts normally slows the simulation enough to minimize loss of messages to the Dashboard Server. Running a Dashboard Server across a network can sometimes impose sufficient delay to reduce the chances of message overload as well. This is the recommended way to use Dashboards. These suggestions may or may not be applicable to your environment, depending on a wide range of factors. You should experiment in your own environment as needed.

The image below shows the Truck Status Dashboard during a run. Note that a Dashboard window cannot be closed. Closing the Dashboard Server's main window closes all associated Dashboard

windows and shuts down the server.



Appendices

APPENDIX A

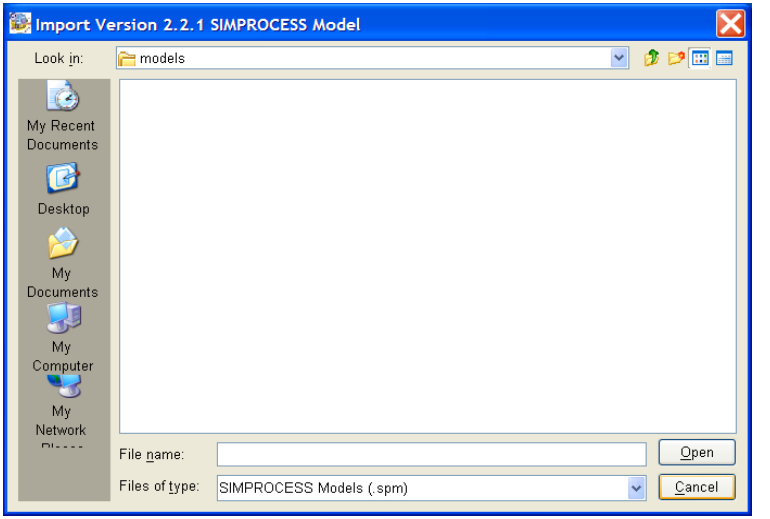
Importing Version 2.2.1 Models

Version 2.2.1 or 2.2.2 models cannot be opened using **File/Open**. Earlier version models must be imported to version 4. This is done using **File/Import/Version 2.2.1 Model...** Model versions earlier than 2.2.1 cannot be imported. These models must be saved in 2.2.1 or 2.2.2 before they can be imported into version 4. However, it is recommended that models be saved in 2.2.3 before importing. SIMPROCESS 2.2.3 is a special Student version (Import Utility) that is designed to prepare models for import to version 4. The 2.2.3 Student version can load and save models from versions of SIMPROCESS earlier than 2.2.1. The special Student version of SIMPROCESS 2.2.3 is available at www.simprocess.com.

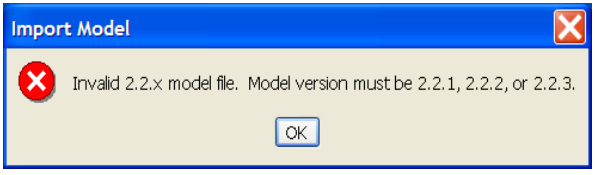
Earlier version models must be imported because the structure of SIMPROCESS and the structure of a SIMPROCESS model file has changed. Version 3 and higher model files are XML files. Thus, they can be read by any XML parser.

Import Procedures

To import a model select **File/Import/Version 2.2.1 Model...** and choose the model to import.



If the file selected is a version 3 or higher file, it will open. However, if the file is pre-2.2.1, an error dialog will appear.



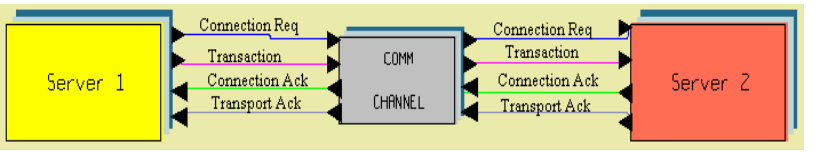
Preparing Your Model For Import

The import procedure reads a 2.2.1, 2.2.2, or 2.2.3 model file and converts the information to XML that can be read by SIMPROCESS version 4 or higher. However, due to limitations in 2.2.1 and 2.2.2 files, some preparation may be required. For larger models, it is recommended that they be opened and saved in 2.2.3. Without being saved in 2.2.3, importing the properties of an Activity, Connector, Pad, etc. from earlier version models depends upon the name of that item. Therefore, if there are duplicate names at the same level, errors will occur, and the conversion will not be complete. Depending on the version of your model, there are three or four primary steps in preparing your model for import. The first item only applies to models that have not been saved in 2.2.3.

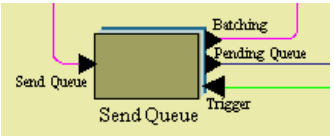
- Make sure there are no duplicate names at the same level (2.2.1 and 2.2.2 only).
- Make sure certain special characters are not in names.
- Make sure all required fields are complete.
- Make sure all special graphics are imported before importing the model.

Duplicate Names (2.2.1 and 2.2.2)

When checking the names, be concerned with names that are at the same level of hierarchy. First, make sure no Activities or Processes have the same name (this should have already been enforced by SIMPROCESS 2.2.*). Second, make sure no Connectors or Pads have the same name as another Connector or Activity/Process. Pads cannot have duplicate names on the same Activity or Process, but they can have duplicate names across Activities/Processes. A Pad cannot have the same name as an Activity or Connector. Finally, make sure everything (Activity, Process, Connector, or Pad) has a name. Version 2.2.2 and earlier will allow you to have Connectors without names. Notice in the example below there are duplicate Connector names. One set of these names will need to be changed for the model to import correctly. A simple solution would be to add a 1 to each Connector name on the right. Note that once the model has been imported the names can be changed back to the original.



The next example shows a Process with a Pad that has the same name. The Process *Send Queue* has a Pad named *Send Queue*. This will cause errors during import.

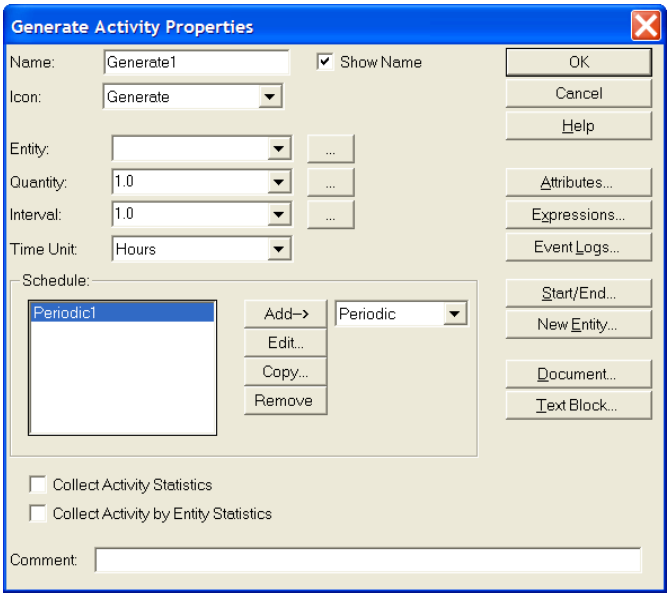


Special Characters

Names of Activities, Processes, Connectors, or Pads cannot have single quotes. These characters will cause errors in the XML parser. For instance, the name *Can't Process* will cause errors. Other characters to avoid are <, >, and /. In general, spaces are not a problem. However, extra spaces will be ignored. Therefore, *Process_1* (one space between *Process* and *1*) is the same as *Process__1* (two or more spaces between *Process* and *1*).

Required Fields

Some Activities have required fields. For instance the Generate Activity needs an entity to generate. Notice the Generate Properties Dialog below. If no entities have been defined in the model, and, thus, the Entity field in the Generate is blank, errors will occur. This same type of error could be caused by Assemble, Batch, and Transform Activities not having an entity type selected. Also, a Branch Activity with no attribute selected when branching by attribute has been set could cause errors during import.



Graphics

If bitmaps were imported for the model, `gif`, `jpeg`, or `png` versions of these bitmaps must be imported before importing the model.

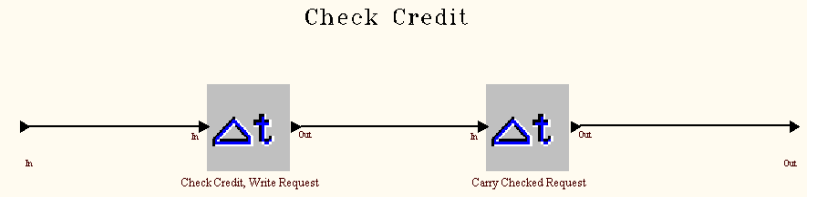
Graphical Import Results

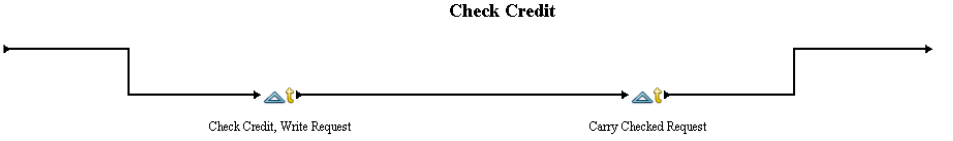
If there are no errors, all properties will import. However, the screens will look different. This is because version 3.0 or higher uses a different coordinate system from earlier SIMPROCESS versions. There are several areas that will be quite noticeably different.

- Activity/Process location
- Activity/Process size
- Connectors not connected to Pads
- Specially drawn Connectors not correct
- Text Blocks, Static labels, and Dynamic labels smaller

Activity/Process Location

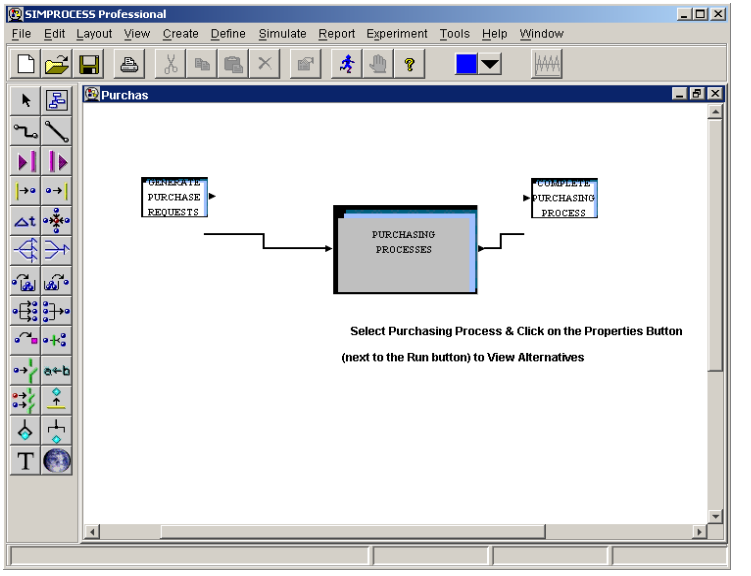
The drawing area for earlier versions of SIMPROCESS was a square. The drawing area for version 3 is a rectangle and is related to your screen size (typically 1024 x 768). Thus, Activities and Processes will be in positions relative to where they were in 2.2.1 or 2.2.2. The change from a square area to a rectangular area will cause some Activities or Processes to be out of place. The two images below demonstrate this. The first is from a 2.2.2 version model. The second is after importing to version 4. Notice that the two delay Activities may be higher or lower in relation to the Process Pads in the imported model.

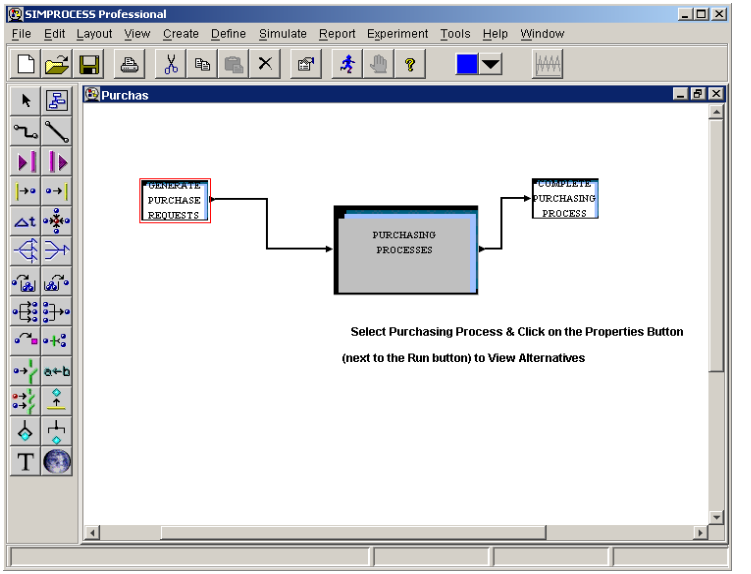




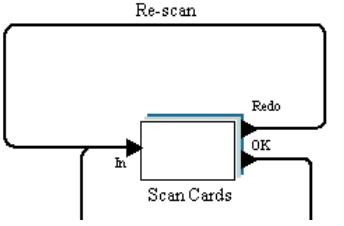
Connectors And Pads

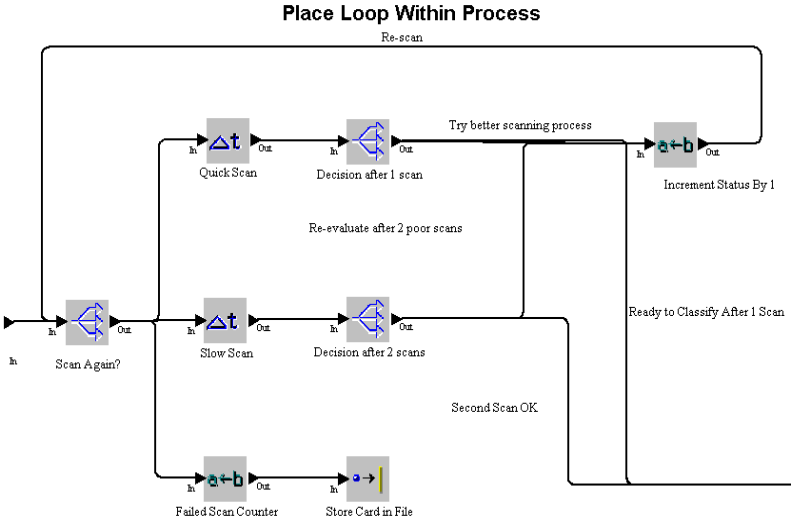
Connectors may not be attached to the Pads. This is due to the changing size of the icons. This is easily fixed by slightly moving one of the Activities or Processes. The images below demonstrate this. The first shows the model as imported. Notice that the Connectors do not connect with the Pads. The second image shows that, after a slight movement of one of the Processes, the Connectors jump into place.



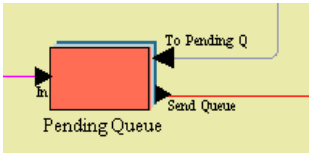


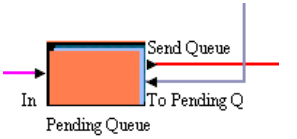
Another issue is a change in Pad rules for version 3 and higher. A Connector cannot go from the output Pad of an Activity or Process to an input Pad of the same Activity or Process. This rule is in place to help prevent infinite loops. Thus, if a 2.2.2 model had a Connector from an output Pad of a Process to an input Pad of the same Process, that Connector will not be in the imported model. This is easily fixed by placing another Activity (like a Merge) between the two, or having the loop occur within the Process. In the example below the *Re-scan* Connector in the 2.2.2 model is not allowed in 3.0 or higher. The solution is to have the loop within the Process.





Also, Pads may be arranged differently. Pads will be on the correct side of an Activity or Process, but they may be in a different order. Notice that the Pads on the right side of the Process *Pending Queue* are swapped. The first image is from the 2.2.2 model, and the second is from the imported model. Pads on other Activities like the Clone, Split, Assemble, and Gate may be swapped as well.

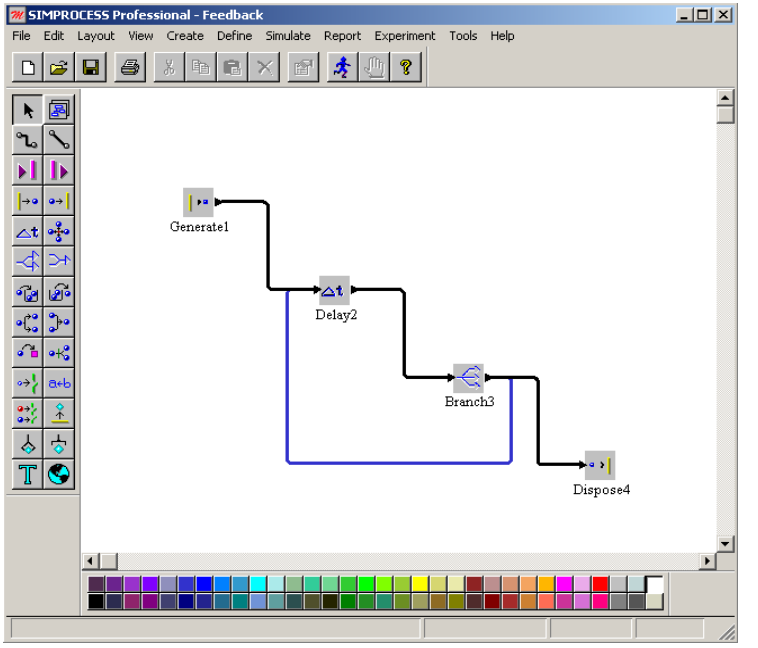




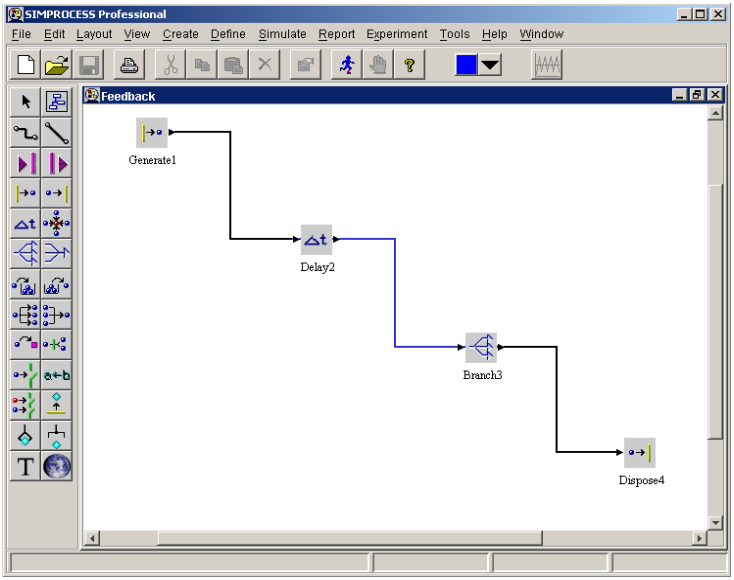
Specially Drawn Connectors

Connectors are drawn by clicking on the output Pad of one Activity and then clicking on the input Pad of another Activity. These Connectors will default to a bent Connector. Special paths for

Connectors are created by clicking on the layout. Every click point creates a right angle. In the 2.2.2 example below, this is how the feedback loop is created (blue Connector).

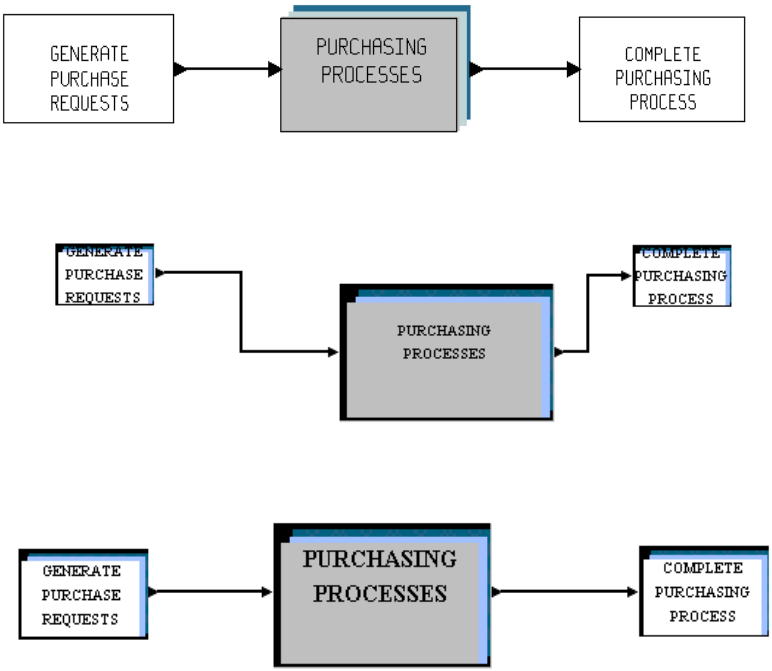


Notice that in the imported model the feedback Connector from Branch3 to Delay2 overlays the Connector from Delay2 to Branch3. This is because the Connector from Branch3 to Delay2 took the default path. Thus, this Connector will need to be deleted and redrawn. Converting Connectors using the vertices of the corners created strange results due to the change in coordinate systems. Using the default Connector between Activities means only special Connectors need to be redrawn.

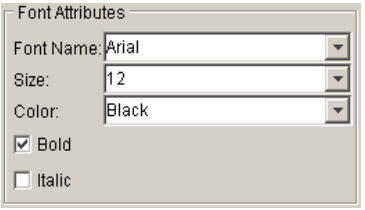


Text Blocks, Static Labels, and Dynamic Labels

Text blocks are labels that can display on Processes or Activities. In earlier versions of SIMPROCESS, the font used for text blocks was a vector font. The font would scale as the Process or Activity was resized. In SIMPROCESS 3 and higher, the text blocks were improved to allow the font attributes (font type, color, size, and style) to be set. This requires using the fonts native to your system. Therefore, the font will not scale as a Process or Activity is resized. During conversion, the default font attributes are used. The default font attributes may not fit the Process or Activity, or the default font attributes may be too small for the Process or Activity. The model below is a 2.2.2 model. The image that follows shows the imported model. Notice that for the outer two Processes the text blocks are too large and for the Process in the middle the text block is too small. Also, notice the location difference of the center Process. For the Processes where the text block is too large, either the Process can be sized larger or the text block can be sized smaller. The third image shows the corrections. The two outer Processes were sized larger. The font size was set larger for the text block for the center Process, and the font style was set to bold. Finally, the **Align** option on the **Edit** menu was used to line up the Processes.

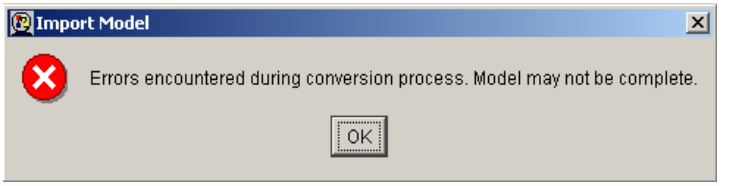


Static and dynamic labels can experience the same results during conversion. Although, labels do not overlay a Process or Activity like a text block, the imported labels may be smaller than desired. Again, this is due to vector fonts being eliminated. To change a label, just open up the properties and change the font attributes.



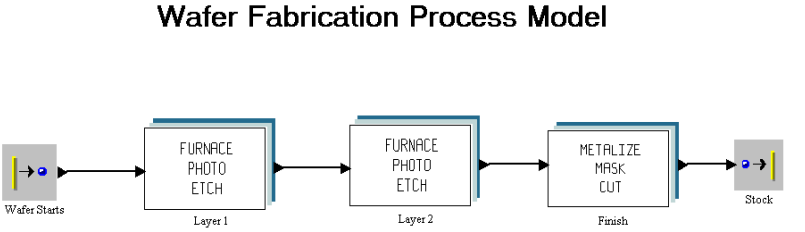
Properties Import Results

If the model has been prepared properly, there should be no errors during the import. If errors do occur, an error dialog will appear.

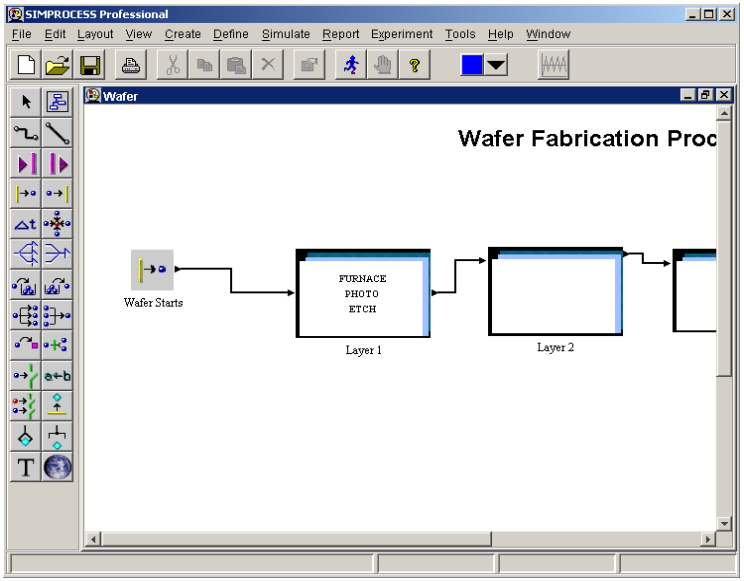


If the error dialog appears, open the `simprocess.log` file in the `SIMPROCESS/SPSYSTEM` directory. This file will contain more detailed error messages. The first error listed is the one to focus on. Normally, the error messages that follow the first one result from the first error.

The image below shows the top level of the 2.2.2 demo model Wafer.spm. This model will be used as an example for diagnosing errors in properties.

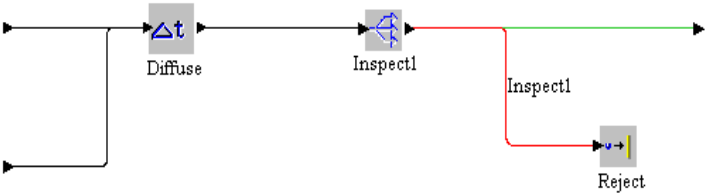


As an example, an import of the 2.2.2 demo model Wafer.spm produced the following error in simprocess.log: **Error in Activity properties of Activity Inspect1 in imported model Wafer**. This error means the problem occurred somewhere close to the Activity named Inspect1. In the image below, notice the graphics of the imported model. The layout shows that the text block is missing from the Process Layer2. Also, the Pads are not in the proper place for Layer2. This indicates that the error occurred in the Process Layer1 since no properties for Layer2 were imported.



To solve this, open the model in SIMPROCESS 2.2.2. or 2.2.1. If you do not know exactly where the Activity named is, you can use the Find Activity feature of the Activity Browser to find it.

Notice that there is a Connector named *Inspect1,* as well as the Activity named *Inspect1*. This is the cause of the problem. Changing the name of the Connector or the Activity is the solution. In this particular model, this same Activity/Connector combination is in Layer2 and needs to be changed there as well. (This error caused by duplicate names will not occur with models saved in 2.2.3.)



Import Troubleshooting

The table below gives sample error messages from the simprocess.log file along with possible causes.

If the error message gives a specific Activity type (such as Assemble, Batch, etc.) there is usually something missing from the properties for that Activity. The errors listed below are the most common. The last four are not specific to a particular Activity type.

If errors persist, contact SIMPROCESS Technical Support at `simprocess@caci.com` for assistance.

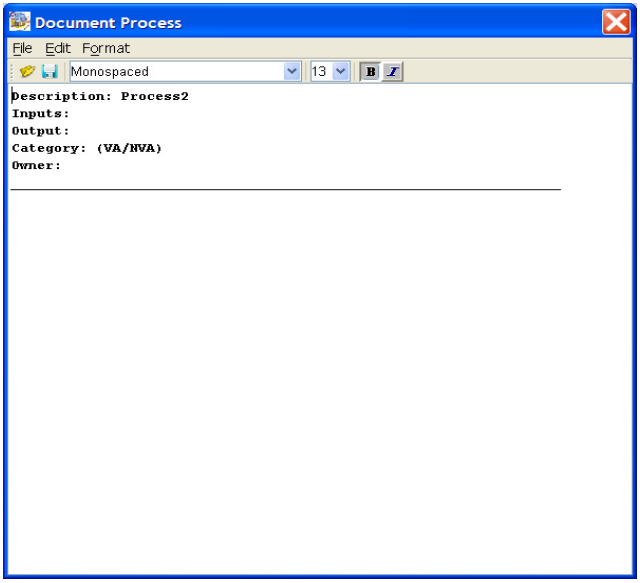
TABLE 1. Import Errors and Causes

Error	Cause
Error in schedules for Generate Generate1 in imported model Feedback	Entity field is blank in a Generate schedule
Error in Activity properties of Activity Inspect1 in imported model Wafer	A Connector or Pad has the same name as the Activity listed (2.2.1 and 2.2.2 only).
Error in Dummy Connector > in imported model Wafer	A Connector is missing a name (2.2.1 and 2.2.2 only).
SPDOM.selectSingleNode exception javax.xml.transform.TransformerException: misquoted literal... expected single quote!	A name has a single quote.
Error in Connector Rejects in imported model Wafer	Two Connectors have the same name (2.2.1 and 2.2.2 only).

Importing Document Files

Versions of SIMPROCESS prior to 3 stored model documentation in files in the model folder. These files will not import automatically. The document feature has been improved in version 3 and higher. No longer is the documentation stored in separate files. In version 3 and higher it is part of the model file. For the documentation to be part of the model, the text must be RTF. The files in earlier version models are ASCII if NotePad was used to create the text or some other format if another text editor (such as MS Word) was used. To import these files they must first be saved as RTF. This is easily done in MS Word. There is also shareware available on the internet that will convert ASCII files to RTF (`http://www.jafsoft.com/asctortf`). The names of the files converted to RTF are not important to SIMPROCESS. Once the files are RTF, simply click the **Document** button on the item for import. There is a **Document** button on all Activity, Process, entity, and resource properties dialogs. Also, there is **Model Documentation** on the **Define** menu.

Clicking the **Document** button brings up an RTF editor.



From the **File** menu choose **Read from File...** This allows you to read in the RTF document files which makes the file a part of your model file.

This must be done for every documentation file that was created for your 2.2.* model. All of these files will be located in the model's folder and will have the extension `.doc`.

APPENDIX B

Activity Summary Table

		Required Parameters	Non-standard Options
Assemble	Receives 2 or more entities and assembles them into a single entity for release.	Component Entity Assembled Entity	Resources Delay Batch Components
Assign	Assigns values to entity attributes.	Entity Attributes	Resources Delay Set Entity Priority
Batch	Stores entities until a condition is met, then releases them as one, while retaining their individual identity.	Quantity to Batch Min Batch Size Max Hold Time Batch Entity Type	Resources Delay
Branch	Routes entities to different paths in the model network.	Branch Type	Resources Delay

		Required Parameters	Non-standard Options
Clone	Clones entities.	Number of Entities	Resources Delay
Delay	General-purpose activity.	Delay Time	Resources
Dispose	Disposes of entities.		Maximum entity Count
Free Resource	Releases resources obtained by Get Resource activities.	Release actions	Release all allocated resources
Gate	Accumulates entities until a condition is met, then releases a specified number of them.	Threshold Release ON/OFF Threshold Release Quantity (if Threshold Release ON) Trigger Release Quantity (if Trigger Release ON)	Resources Delay Batch released entities
Generate	Generates entities.	Entity type Quantity Interval	Start and End dates) Schedule Type Schedule Items
Get Resource	Obtains resources to be held during several activities.	Resources Tag attached to allocation	
Join	Reunites entities divided at a Split activity.	Family Name	Batch family members Resources Delay
Merge	Merges entities and routes them in a single stream.		
Replenish Resource	Adds units to consumable resources.	Replenish actions (Resource and Units)	
Split	Divides one entity into several to model the division of processing among several activities.	Family name	Copy Priority Resources Delay
Synchronize	Coordinates the release of various entities.	Number of Pads	Resources Delay

		Required Parameters	Non-standard Options
Transfer	Transfers entities from one portion of a model to another without a connector, or transfers an entity to another SIMPROCESS model.	Send or Receive Local or Remote Connection or Protocol	Most standard options are not available
Transform	Transforms arriving entities from one type to another, and releases one or more of the new type.	Number of Output Entities Output Entity type	Copy Attributes Resource Delay
Unbatch	Separates a batched entity into its constituent parts.		Resource Delay Retain Batched Entity Unbatch Nested Batches

APPENDIX C

SIMPROCESS File Structure

The SIMPROCESS installation program creates a directory called `SIMPROCESS` (unless a different name is chosen during installation). In this directory there are a number of important files and up to nine subdirectories. The primary subdirectories are the System Directory (`SPSYSTEM`), the User Working Directory (`SPUser`), and the `models` directory. This appendix briefly describes the structures and contents of the directories. The basic directory structure is listed below. Note that the `dispatcher` directory only exists if the SIMPROCESS Dispatcher is installed.

```
SIMPROCESS installation directory
   SPSYSTEM
         xfit (Windows only)
   SPUser
         document
         SampleFiles
   models
         Demos
         ExpressionDemos
   metamodel
   endorsed
   jre
   ext
   dashboardserver
   timeserver
```

```
                dispatcher (optional)
```

Installation Directory

```
ReadMe.txt                   ( ReadMe file with summary of changes )
installvariables.properties  ( Installer settings )
SIMPROCESS_InstallLog.log    ( Installation log )
.com.zerog.registry.xml      ( Installer file )
SIMPROCESS.ico               ( SIMPROCESS icon - Windows only )
InstallScript.iap_xml        ( Installation file )
Uninstall SIMPROCESS.exe     ( Uninstaller application - Windows only )
Uninstall SIMPROCESS         ( Uninstaller application - non-Windows sys-
                               tems )
Uninstall SIMPROCESS.lax     ( Uninstaller application settings file )
uninstaller.jar              ( Uninstaller file )
Dispatcher.exe               ( Optional Dispatcher application - Windows
                               only )
Dispatcher                   ( Optional Dispatcher application - non-Win-
                               dows systems )
Dispatcher.lax               ( Optional Dispatcher application settings
                               file )
lax.jar                      ( Installer file )
SPRunSimulation.exe          ( SIMPROCESS with no GUI - Windows only )
SPRunSimulation              ( SIMPROCESS with no GUI - non-Windows )
SPRunSimulation.lax          ( Application settings file )
SIMPROCESS.exe               ( SIMPROCESS executable - Windows only )
SIMPROCESS                   ( SIMPROCESS executable - non-Windows )
SIMPROCESS.lax               ( Application settings file )
MetamodelEditor.exe          ( Metamodel Editor executable - Windows only )
MetamodelEditor              ( Metamodel Editor executable - non-Windows )
MetamodelEditor.lax          ( Application settings file )
MetamodelEditor.ico          ( Metamodel Editor icon - Windows only )
java2rei.dll                 ( Rose Java interface library - Windows only )
lmutil.exe                   ( Licensing file - Windows only )
lmutil                       ( Licensing file - non-Windows )
hostid.txt                   ( Licensing file )
hostid.bat                   ( Licensing file - Windows only )
hostid.sh                    ( Licensing file - non-Windows )
License.htm                  ( SIMPROCESS License agreement )
Import Procedures.pdf        ( Documentation for importing 2.2.1 models )
```

SPSYSTEM Directory

```
InstallSettings.win.xml ( defaults for some preference settings - Windows
only )
InstallSettings.lnx.xml ( defaults for some preference settings - Linux
only )
jh.jar              ( SIMPROCESS executable jar file )
plot.jar            ( SIMPROCESS executable jar file )
simprocess.jar      ( SIMPROCESS executable jar file )
SPHelp.jar          ( SIMPROCESS executable jar file )
SPRemote.jar        ( SIMPROCESS executable jar file )
xalan-j.jar         ( SIMPROCESS executable jar file )
OptQuest.jar        ( SIMPROCESS executable jar file )
java2rei.jar        ( SIMPROCESS executable jar file - Windows only)
jcommon.jar         ( SIMPROCESS executable jar file )
jfreechart.jar      ( SIMPROCESS executable jar file )
jakarta-poi.jar     ( SIMPROCESS executable jar file )
modelfit.jar        ( SIMPROCESS executable jar file )
jcalendar.jar       ( SIMPROCESS executable jar file )
commons-io.jar      ( SIMPROCESS executable jar file )
metamodel.jar       ( SIMPROCESS executable jar file )
xbean.jar           ( SIMPROCESS executable jar file )
simprocess.err      ( SIMPROCESS application error messages; created and/
or emptied when SIMPROCESS is run )
simprocess.log      ( SIMPROCESS application messages; created and/or emp-
tied when SIMPROCESS is run )
optQuest.log        ( OptQuest for SIMPROCESS application messages )
optQuest.err        ( OptQuest for SIMPROCESS application error messages )
GetStart.pdf        ( documentation file )
SPUser.pdf          ( documentation file )
Metamodel.pdf       ( documentation file )
RoseExists.dll      ( SIMPROCESS Rose library - Windows only )
license.dll         ( SIMPROCESS license library - Windows only)
libLinux.so         ( SIMPROCESS license library - Linux only )
license.dat         ( license file obtained from CACI )
```

xfit Subdirectory

This directory only exists on Windows systems and contains the files necessary to run the ExpertFit application.

SPUser Directory

```
sProcDB.properties      ( database connection properties - required to use
the SIMPROCESS database )
mysql.sProcDB.properties( sample database connection properties for use
```

```
with a MySQL database; may serve as a template for other database tools )
SimProcDB.mdb            ( MS Access database - Windows only )
simprocessdb.sql         ( sample DDL statements to create a "simprocess"
database in MySQL for storing Experiment results; may serve as a template
for other database tools )
UserPreferences.xml      ( created on first run, user preferences stored
here )
UserFiles.jar            ( created when importing application graphics and
icons, or when saving Libraries )
Experiments.xml          (created when experiments are defined or imported)
```

document Subdirectory

This directory is used to customize headings for Activity, Entity, Connector, Resource, and model documentation (**Document** button on properties dialogs). The directory is empty initially. The headings are customized with the use of text files that have the extension `.txt`. Each line of a file is considered a heading. For instance, the lines

```
Activity Name:
Resources Used:
```

in a file would be considered two separate headings. The contents of the `.txt` files completely replace the default headings.

Listed below are the names that can be used for the `.txt` files.

- `Activity.txt` - changes the headings for all Activities
- `process.txt` - changes the headings for processes
- `Entity.txt` - changes the headings for Entity types
- `Resource.txt` - changes the headings for Resources
- `Connector.txt` - changes the headings for Connectors
- `model.txt` - changes the headings for the **Model Description...** (**Define** menu).

The file `Activity.txt` changes the headings for all Activities. To change the documentation headings for a specific Activity, name the file the same name as the type of the Activity along with the `.txt` extension. Some examples are `delay.txt`, `replenishResource.txt`, `assemble.txt`, and `getResource.txt`. Notice that the type of the Activity must be spelled out completely with no spaces in the file name.

Not all files are required. If only the document headings for Entity types need to be changed, then `Entity.txt` is the only file that needs to exist.

There are sample files in the `SampleFiles/document` directory.

SampleFiles Subdirectory

This directory contains the source code for the files in the `com.caci.demo` package in `SPRemote.jar`. Also, sample batch files and scripts that start the Java RMI Registry, SPServer, and SPPlotServer are included, which can be copied and used as templates if desired. There is a `documents` subdirectory that contains sample files for modifying document headings.

models Directory

SIMPROCESS defaults to this directory as its starting point when saving or opening models.

Demos Subdirectory

This directory contains demonstration and reference models. See Chapter 5 of the *SIMPROCESS Getting Started Manual* for a discussion of each model.

ExpressionDemos Subdirectory

This directory contains models that demonstrate some advanced features of SIMPROCESS available through the SIMPROCESS Expression Language. `SIMPROCESS Expression Demo Models.pdf`, which is located in this directory, has a brief explanation of each model.

metamodel Directory

Directory containing SIMPROCESS metamodels. Metamodels must be saved to or opened from this directory.

endorsed Directory

```
saaj-api.jar         ( SIMPROCESS executable jar file )
saaj-impl.jar        ( SIMPROCESS executable jar file )
jaxrpc-api.jar       ( SIMPROCESS executable jar file )
jaxrpc-impl.jar      ( SIMPROCESS executable jar file )
jaxrpc-spi.jar       ( SIMPROCESS executable jar file )
activation.jar       ( SIMPROCESS executable jar file )
sjsxp.jar            ( SIMPROCESS executable jar file )
mail.jar             ( SIMPROCESS executable jar file )
relaxngDatatype.jar  ( SIMPROCESS executable jar file )
xsdlib.jar           ( SIMPROCESS executable jar file )
jsr173_api.jar       ( SIMPROCESS executable jar file )
```

```
FastInfoSet.jar      ( SIMPROCESS executable jar file )
```

jre Directory

This directory contains the Java Runtime Environment referenced by the SIMPROCESS program.

ext Directory

This directory is a secondary location for adding external Java classes to SIMPROCESS. The preferred location is the `classes` directory within a model's directory (see "Model-Specific Java Additions," beginning on page 604 and "Method ExternalCall:," beginning on page 567 for more information).

dashboardserver Directory

This directory contains the files required to run a Dashboard Server. (See "Displaying Dashboards" on page 447.)

timeserver Directory

This directory contains the files required to run the SIMPROCESS TimeServer. See "Time Server," beginning on page 113 and `SIMPROCESS TimeServer.pdf` in this directory for more information on the TimeServer.

dispatcher Directory

This directory is only created if SIMPROCESS and Dispatcher is selected during installation. The files are for using SIMPROCESS with a Web service. See `SIMPROCESS Dispatcher.pdf` for more information.

APPENDIX D

Statistical Distributions

The following pages give a brief description of the standard statistical distributions available in SIMPROCESS, as well as their required parameters.

Most of the parameters for continuous distributions can be classified, on the basis of their physical or geometric interpretation, as being one of three basic types: location, scale, or shape parameters. The following discussion is taken from the book *Simulation Modeling and Analysis* (Third Edition) by Law and Kelton (2000).

A location parameter l specifies an abscissa (x axis) location point of a distribution's range of values; usually, l is the midpoint (e.g., the mean of a normal distribution) or lower endpoint (e.g., location for a Pearson type V distribution) of the distribution's range. As l changes, the associated distribution merely shifts left or right without otherwise changing. Also, if the distribution of the random variable X has a location parameter of 0, then the distribution of the random variable $Y = X + l$ has a location parameter of l.

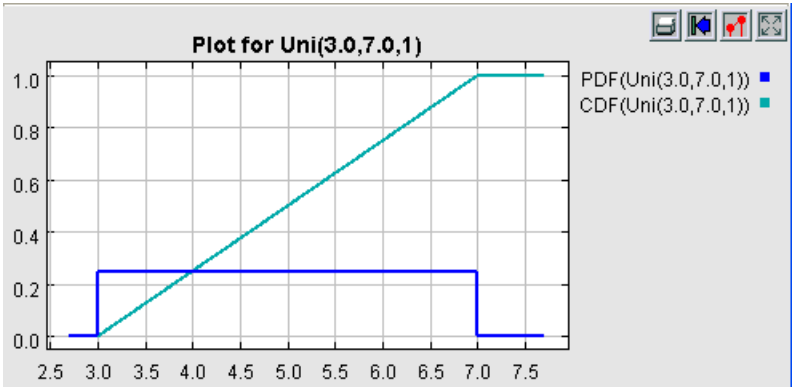
A scale parameter b determines the scale (or unit) of measurement of the values in the range of the distribution. (The standard deviation is a scale parameter for the normal distribution.) A change in b compresses or expands the associated distribution without altering its basic form. Also, if the random variable X has a scale parameter of 1, the distribution of the random variable $Y = bX$ has a scale parameter of b.

A shape parameter a determines, distinct from location and scale, the basic form or shape of a distribution with the general family of distributions of interest. A change in a generally alters a distribution's properties (e.g., skewness) more fundamentally than a change in location or scale. Some

distributions (e.g., exponential and normal) do not have a shape parameter, while others (e.g., beta and Pearson type VI) may have two.

The last parameter of each distribution is the stream number.This is the random-number stream that will be used to general random values from the distribution. Possible values for stream are 1, 2, …, 215, with 1 being the default.

Uniform Distribution

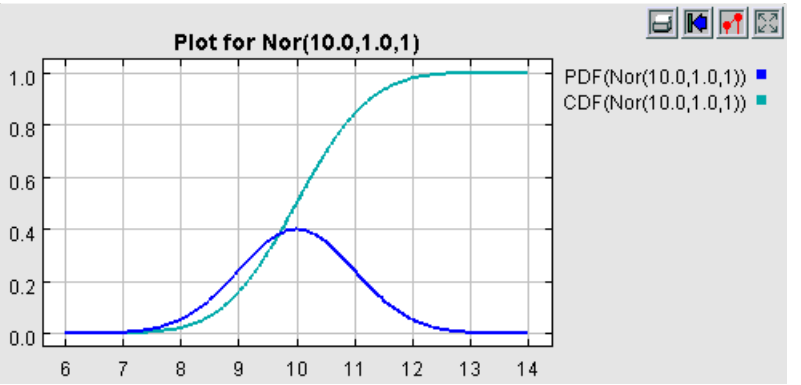


Probability density function and cumulative density function for a uniform distribution with minimum = 3 and maximum = 7.

Syntax: Uni(minimum, maximum, stream)

The uniform distribution (continuous) is equally likely to take on any real number in the finite interval [**minimum**, **maximum**] (**minimum** >= 0.0 and **maximum** > **minimum**). The real numbers produced by a random-number generator (appear to) have a uniform distribution on the interval [0, 1].

Normal Distribution



Probability density function and cumulative density function for normal distribution function with mean = 10, standard deviation = 1. There are two normal distributions in SIMPROCESS. One only returns non-negative values (zero or higher), and the other will return negative values. For both it is required that **standard deviation** > 0.0.

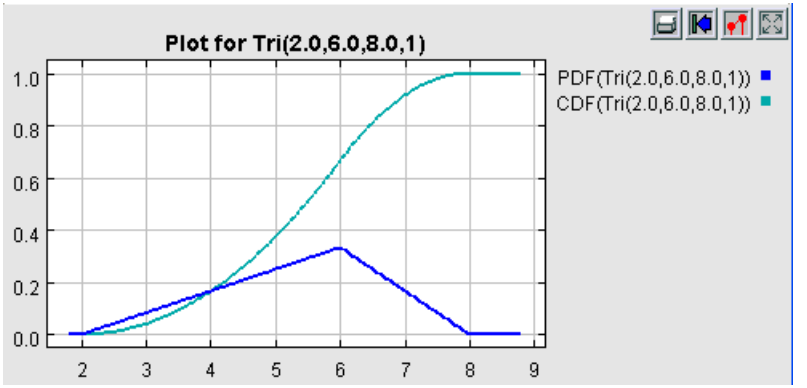
Syntax: Nor(mean, standard deviation, stream) - returns only non-negative values

This distribution is similar to the classical normal distribution, but if a negative value is generated, it is rejected and new values are generated until a non-negative value is generated. In general, this distribution will not be a good model for the time required to perform some task, since task-time distributions are almost always *skewed to the right*.

Syntax: Nrm(mean, standard deviation, stream) - unbounded

This is the classical normal distribution, which is found in most statistics books. It takes on real values between minus infinity and plus infinity. The density function is the familiar "bell-shaped" curve, which is symmetric about the **mean**. The probability that a value is between the **mean** minus 2 **standard deviations** and the **mean** plus two **standard deviations** is approximately 0.95. This distribution should not be used to model the time required to perform some task, since the normal distribution can take on negative values. Furthermore, as stated above, the distribution of the time to perform some task is almost always *skewed to the right*, rather than being symmetric.

Triangular Distribution

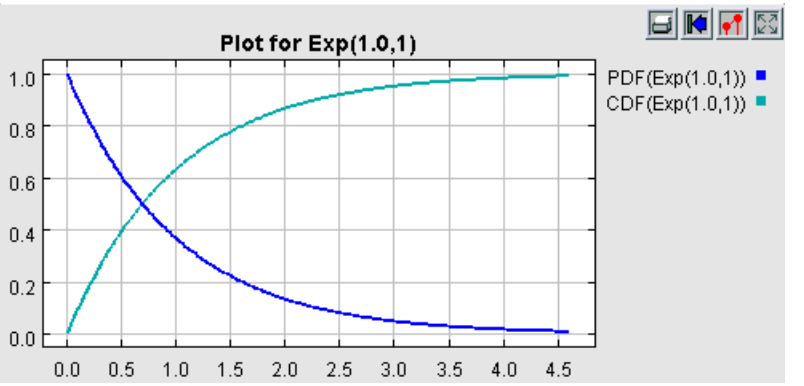


Probability density function and cumulative density function for a triangular distribution with minimum = 2, mode = 6, and maximum = 8.

Syntax: Tri(minimum, mode, maximum, stream)

The triangular distribution (continuous) is typically used as a rough model for the time required to perform some task when no real-world data are available. A triangular distribution takes on values in the finite interval [**minimum**, **maximum**] (**minimum** >= 0.0, **mode** > **minimum**, and **maximum** > **mode**), with values near the **mode** being most likely to occur. Subjective estimates of the three parameters are obtained from subject-matter experts. The mean of a triangular distribution is only equal to the **mode** when the distribution is symmetric.

Exponential Distribution

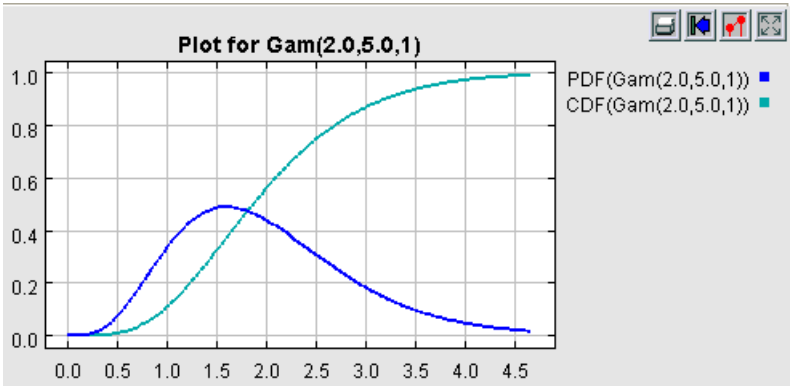


Probability density function and cumulative density function for an exponential distribution with mean = 1.

Syntax: Exp(mean, stream)

The exponential distribution (continuous) is commonly used to model interarrival times of customers to some system when the arrival rate is approximately constant over the time period of interest. It is also sometimes used to model the time to failure of a piece of equipment. The mean of an exponential distribution is a scale parameter and must be greater than 0.0. An exponential distribution with **mean** = *m* is a gamma distribution with **mean** = *m* and **shape** = 1. An exponential distribution with **mean** = *m* is a Weibull distribution with **shape** = 1 and **scale** = *m*. If interarrival times of customers have an exponential distribution with **mean** = *m*, then the number of arrivals in any time interval of length t has a Poisson distribution (discrete) with **mean** = *t/m*.

Gamma Distribution

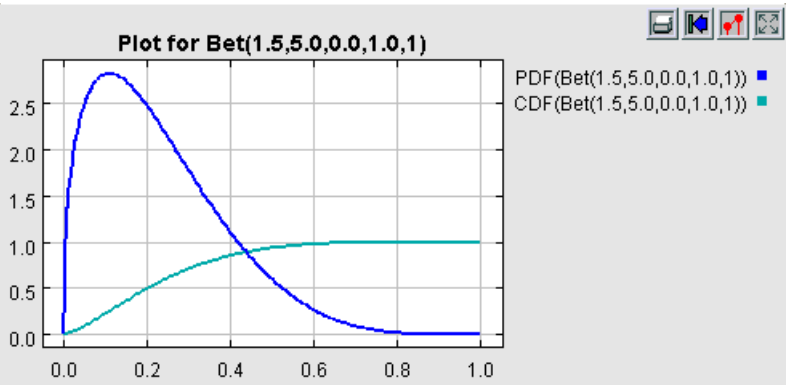


Probability density curve and cumulative density function for a gamma distribution with mean = 2 and shape = 5.

Syntax: Gam(mean, shape, stream)

The gamma distribution (continuous) could be used to model the time required to perform some task. If a gamma distribution has parameters **mean** = *m* and **shape** = *a*, then *b* = *m/a* is a scale parameter. A gamma distribution with **mean** = *m* and **shape** = 1 is an exponential distribution with **mean** = *m*. When **shape** is a positive integer, the gamma distribution is an Erlang distribution. Parameter restrictions are **mean** >= 0.0 and 0.0 < **shape** < 100.0.

Beta Distribution

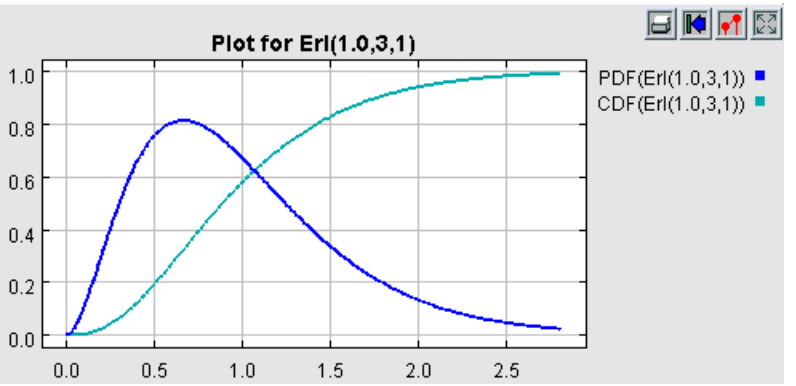


Probability density function and cumulative density function for a beta distribution with shape1 = 1.5, shape2 = 5.0, minimum = 0.0, and maximum = 1.0.

Syntax: Bet(shape1, shape2, minimum, maximum, stream)

The beta distribution (continuous) could be used to model the time required to perform some task when the possible values are restricted to the finite interval [**minimum**, **maximum**] (**minimum** >= 0.0, **maximum** >= 1.0, and **maximum** > **minimum**). Parameter restrictions for **shape1** and **shape2** are **shape1** >= 0.0 and **shape2** > 0.0. The density function is skewed to the left, symmetric, or skewed to the right if **shape1** > **shape2**, **shape1** = **shape2**, or **shape1** < **shape2**, respectively. A beta distribution with **shape1** = **shape2** = 1 is a uniform distribution with the interval [0, 1].

Erlang Distribution

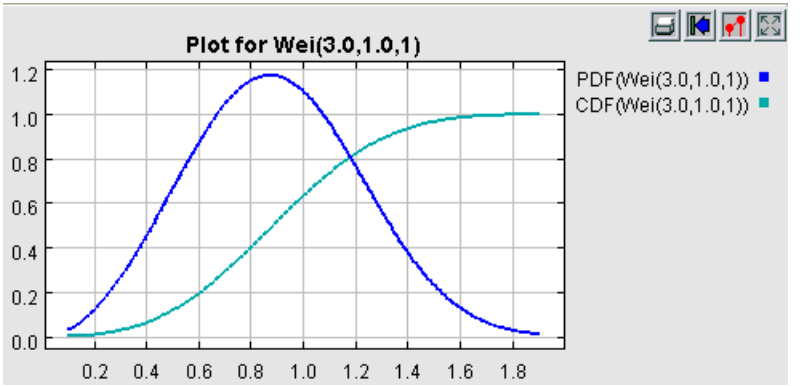


Probability density function and cumulative density function for an Erlang distribution with mean = 1 and shape = 3.

Syntax: Erl(mean, shape, stream)

The Erlang distribution (continuous) could be used to model the time required to perform some task. If an Erlang distribution has parameters **mean** = *m* and **shape** = *a*, then *b* = *m/a* is a scale parameter. An Erlang distribution is just a gamma distribution whose shape parameter is a positive integer. The sum of *k* exponential random variables with **mean** = *m* is an Erlang distribution with **mean** = *km* and **shape** = *k*. Parameter restrictions are **mean** >= 0.0 and 0.0 < **shape** < 100.0.

Weibull Distribution

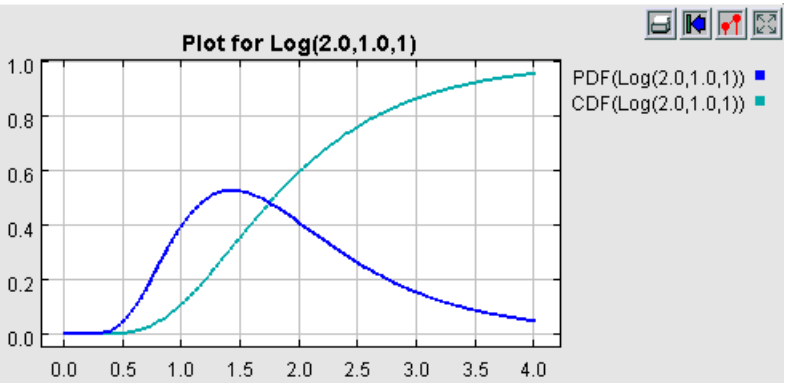


Probability density function and cumulative density function for a Weibull distribution with shape = 3 and scale = 1.

Syntax: Wei(shape, scale, stream)

The Weibull distribution (continuous) could be used to model the time required to perform some task. It is also sometimes used to model the time to failure of a piece of equipment. A Weibull distribution with parameters **shape** = 1 and **scale** = *b* is an exponential distribution with **mean** = *b*. The Weibull distribution is skewed to the left when **shape** > 3.6. Parameter restrictions are **shape** >= 0.0 and **scale** > 0.0.

Lognormal Distribution

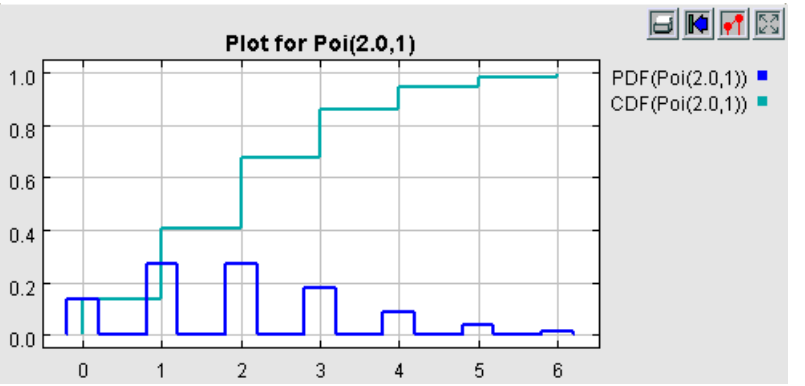


Probability density function and cumulative density function for a lognormal distribution with mean = 2 and standard deviation = 1.

Syntax: Log(mean, standard deviation, stream)

The lognormal distribution could be used to model the time required to perform some task when "large" values sometimes occur. It is always skewed to the right and it has a longer right tail than the gamma or Weibull distributions. The lognormal distribution is closely related to the classical normal distribution - see the book *Simulation Modeling and Analysis* (Third Edition) by Law and Kelton (2000) for details. Furthermore, the parameters of the lognormal distribution, namely, **mean** and **standard deviation**, correspond to the lognormal distribution and are *not* the mean and standard deviation of the corresponding normal distribution. Parameter restrictions are **mean** > 0.0 and **standard deviation** > 0.0.

Poisson Distribution

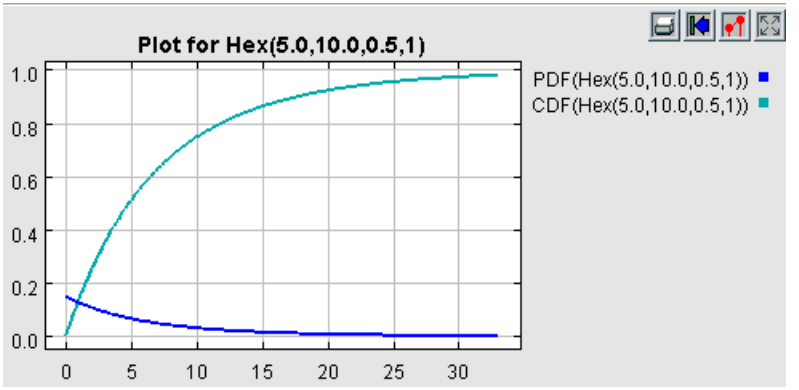


Poisson distribution with mean = 2.

Syntax: Poi(mean, stream)

The Poisson distribution (discrete) with **mean** = *m* is the distribution of the number of customers that arrive to some system in any time interval of length 1 when the interarrival times have an exponential distribution (continuous) with **mean** = 1/*m*. **Mean** must be greater than 0.0.

Hyper Exponential Distribution

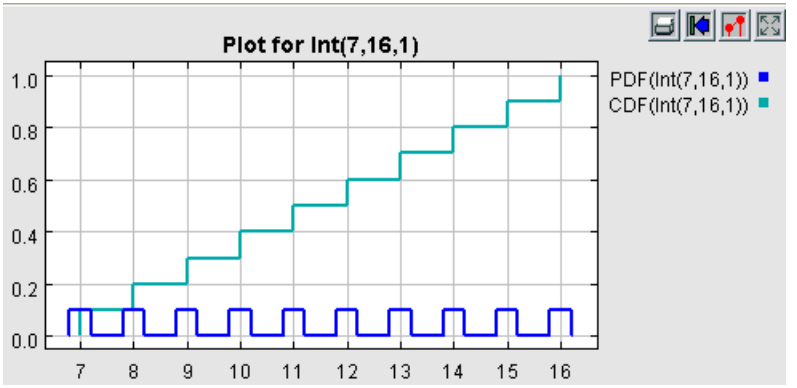


Hyper exponential distribution with mean1 = 5, mean2 = 10, and probability1 = 0.5.

Syntax: Hex(mean1, mean2, probability1, stream)

The hyper exponential distribution (continuous) is a mixture of two exponential distributions. Specifically, a hyper exponential distribution with parameters **mean1**, **mean2**, and **probability1** takes on values from an exponential distribution with parameter **mean1** with a probability of **probability1** and takes on values from an exponential distribution with parameter **mean2** with a probability of 1 - **probability1**. A hyper exponential distribution with **probability1** = 1 is an exponential distribution with parameter **mean1**. Parameter restrictions are **mean1** >= 0.0, **mean2** > 0.0, and 0.0 <= **probability1** <= 1.0.

Uniform Integer Distribution

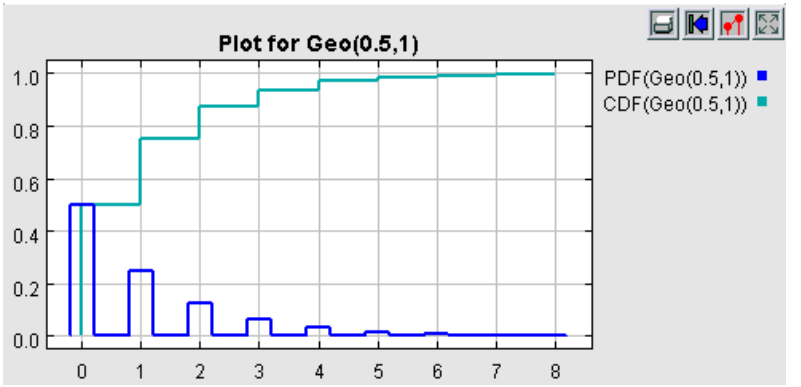


Probability density function and cumulative density function for uniform integer distribution with minimum = 7 and maximum = 16.

Syntax: Int(minimum, maximum, stream)

An uniform integer distribution (discrete) is equally likely to take on any integer in the finite interval [**minimum**, **maximum**], where **minimum** and **maximum** are integers with **minimum** >= 0 and **minimum** < **maximum**.

Geometric Distribution

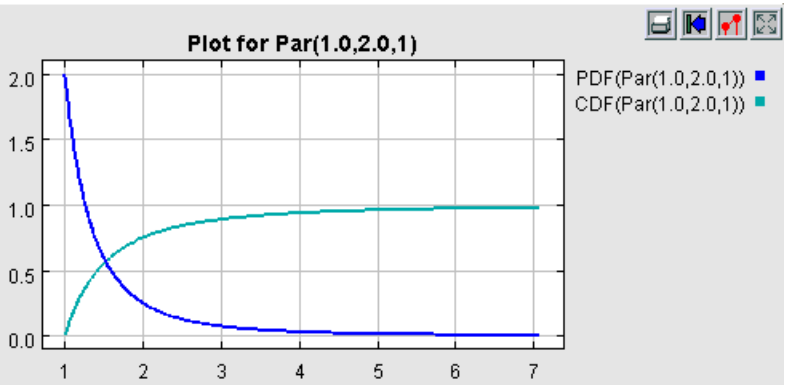


Probability density function and cumulative density function for a geometric distribution with probability = 0.5.

Syntax: Geo(probability, stream)

The geometric distribution (discrete) with **probability** = *p* can be thought of as the distribution of the number of failures before the first success in a sequence of independent Bernoulli trials, where success occurs on each trial with a probability of *p* and failure occurs on each trial with a probability of 1 - *p*.

Pareto Distribution

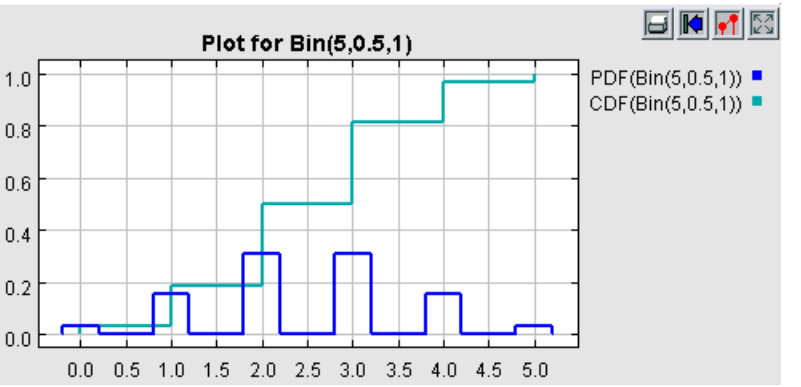


Probability density function and cumulative density function for a Pareto distribution with location = 1 and shape = 2.

Syntax: Par(location, shape, stream)

The Pareto distribution (continuous) could be used to the model interarrival times of customers (e.g., messages) when the traffic is bursty. The mean and variance are finite only if **shape** > 2. Parameter restrictions are **location** >= 0.0 and **shape** > 0.0.

Binomial Distribution

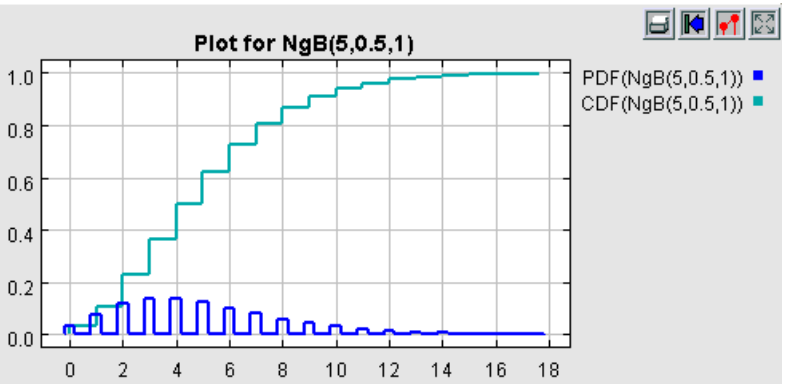


Probability density function and cumulative density function for a binomial distribution with trials = 5 and probability = 0.5.

Syntax: Bin(trials, probability, stream)

The binomial distribution (discrete) with parameters **trials** = t (a positive integer) and **probability** = p can be thought of as the distribution of the number of successes in t independent Bernoulli trials, where success occurs on each trial with a probability of p and failure occurs on each trial with a probability of 1 - p. A binomial distribution with **trials** = 1 is called a Bernoulli distribution with **probability** = p.

Negative Binomial Distribution

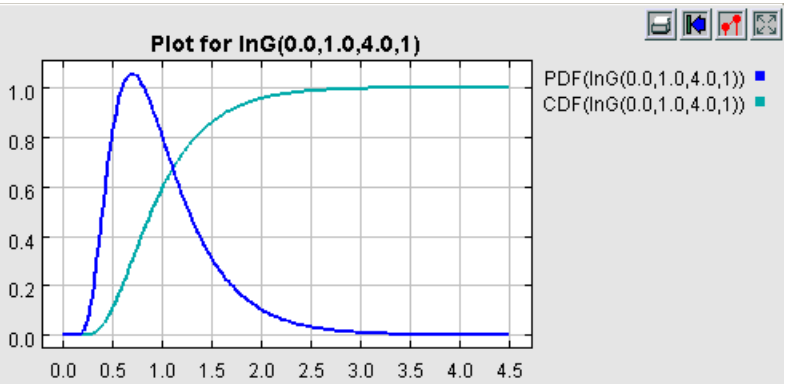


Probability density function and cumulative density function for a negative binomial distribution with s = 5 and probability = 0.5.

Syntax: NgB(s, probability, stream)

The negative binomial distribution (discrete) with parameters **s** (> 0.0) and **probability** = *p* can be thought of as the distribution of the number of failures before the **s**th success in a sequence of independent Bernoulli trials, where success occurs on each trial with a probability of *p* and failure occurs on each trial with a probability of 1 - *p*. A negative binomial distribution with parameters **s** = 1 and **probability** = *p* is a geometric distribution with **probability** = *p*.

Inverse Gaussian Distribution

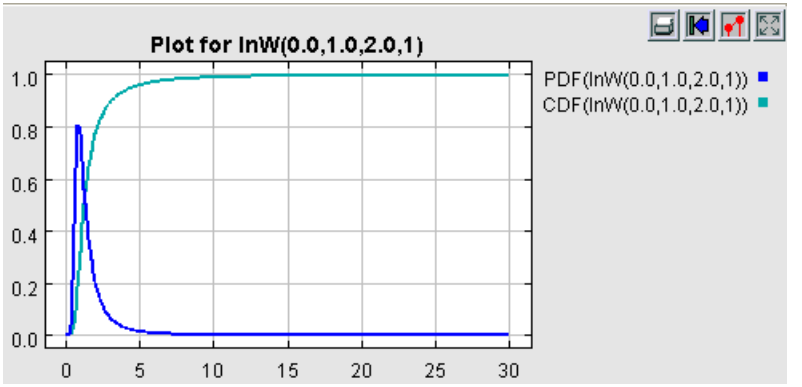


Probability density function and cumulative density function for an inverse Gaussian distribution with location = 0, scale = 1, and shape = 4.

Syntax: InG(location, scale, shape, stream)

The inverse Gaussian distribution (continuous) could be used to model the time required to perform some task. Parameter restrictions are **scale** > 0.0 and **shape** > 0.0.

Inverted Weibull

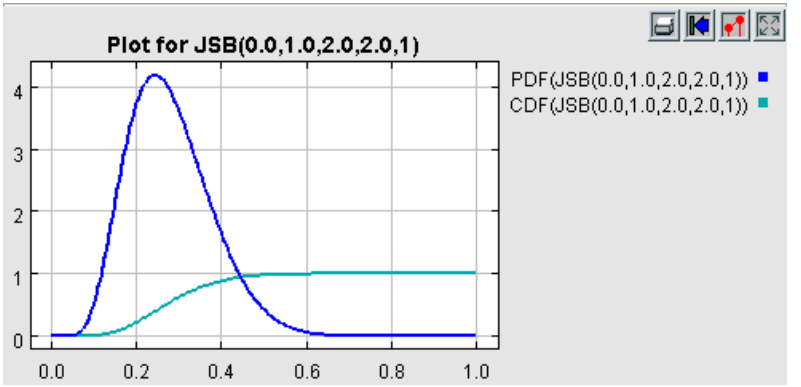


Probability density function and cumulative density function for an inverted Weibull distribution with location = 0, scale = 1, and shape = 2.

Syntax: InW(location, scale, shape, stream)

The inverted Weibull distribution (continuous) could be used to model the time required to perform some task. The mean and variance are finite only if **shape** > 2. If the random variable X has an inverted Weibull distribution with location = 0, scale = b, and shape = a, then Y = 1/X has a Weibull distribution with scale = 1/b and shape = a. (The location parameter is 0.) Parameter restrictions are **scale** > 0.0 and **shape** > 0.0.

Johnson S_B Distribution

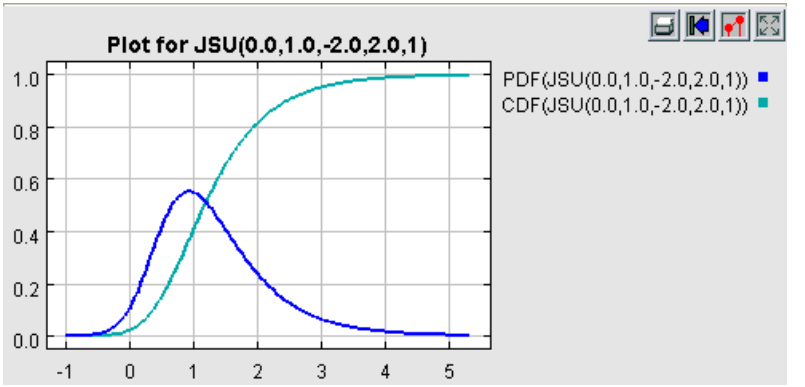


Probability density function and cumulative density function for a Johnson S_B distribution with minimum = 0, maximum = 1, shape1 = 2, and shape2 = 2.

Syntax: JSB(minimum, maximum, shape1, shape2, stream)

The Johnson S_B distribution (continuous) could be used to model the time required to perform some task when the possible values are restricted to the finite interval [**minimum**, **maximum**]. The density function is skewed to the left, symmetric, or skewed to the right if **shape1** > 0, **shape1** = 0, or **shape1** < 0, respectively. The Johnson S_B distribution is closely related to the classical normal distribution - see the book *Simulation Modeling and Analysis* (Third Edition) by Law and Kelton (2000) for details. Parameter restrictions are **shape2** > 0.0 and **maximum** > **minimum**.

Johnson S_U Distribution

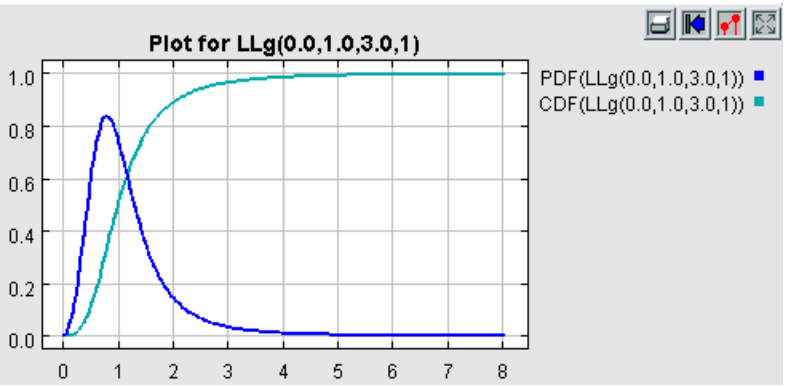


Probability density function and cumulative density function for a Johnson S_U distribution with location = 0, scale = 1, shape1 = -2, and shape2 = 2.

Syntax: JSU(location, scale, shape1, shape2, stream)

The Johnson S_U distribution (continuous) could be used to model a random variable that can take on any value between minus infinity and plus infinity. The density function is skewed to the left, symmetric, or skewed to the right if **shape1** > 0, **shape1** = 0, or **shape1** < 0, respectively. The Johnson S_U distribution is closely related to the classical normal distribution - see the book *Simulation Modeling and Analysis* (Third Edition) by Law and Kelton (2000) for details. Parameter restrictions are **scale** > 0.0 and **shape2** > 0.0.

Log-Logistic Distribution

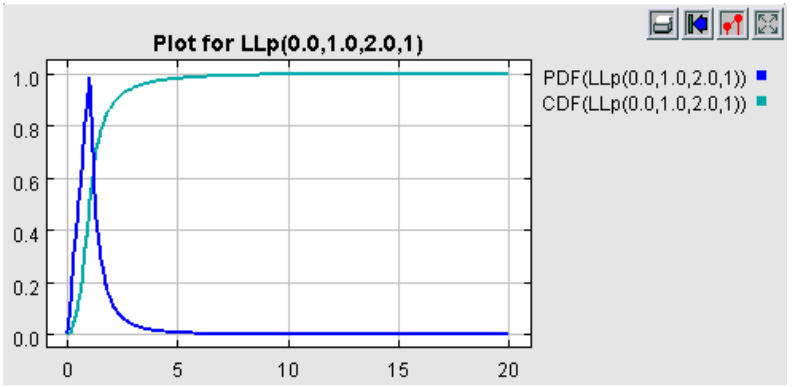


Probability density function and cumulative density function for a Log-Logistic distribution with location = 0, scale = 1, and shape = 3.

Syntax: LLg(location, scale, shape, stream)

The log-logistic distribution (continuous) could be used to model the time required to perform some task. The mean and variance are finite only if **shape** > 2. Parameter restrictions are **scale** > 0.0 and **shape** > 0.0.

Log-Laplace Distribution

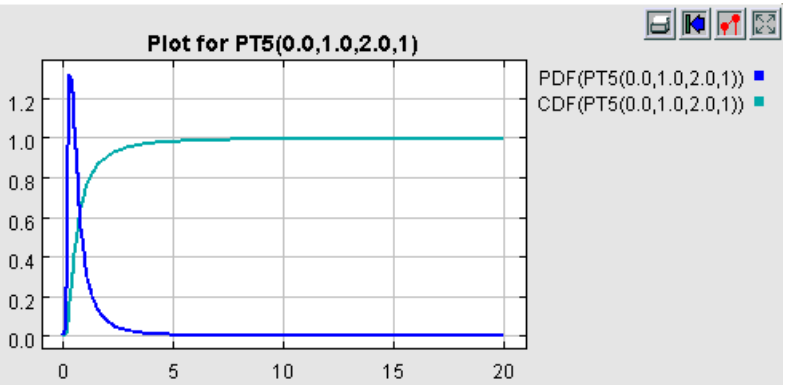


Probability density function and cumulative density function for a log-Laplace distribution with location = 0, scale = 1, and shape = 2.

Syntax: LLp(location, scale, shape, stream)

The log-Laplace distribution (continuous) could be used to model the time required to perform some task. The mean and variance are finite only if **shape** > 2. Parameter restrictions are **scale** > 0.0 and **shape** > 0.0.

Pearson Type V Distribution

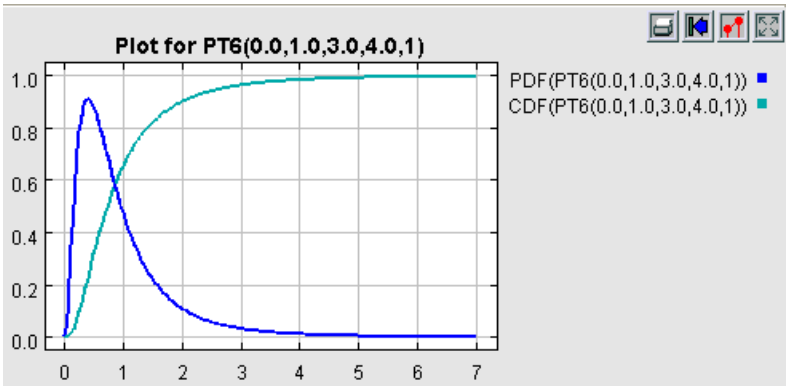


Probability density function and cumulative density function for a Pearson type V distribution with location = 0, scale = 1, and shape = 2.

Syntax: PT5(location, scale, shape, stream)

The Pearson type V distribution (continuous) could be used to model the time required to perform some task. The mean and variance are finite only if **shape** > 2. The Pearson type V distribution is closely related to the gamma distribution - see the book *Simulation Modeling and Analysis* (Third Edition) by Law and Kelton (2000) for details. Parameter restrictions are **scale** > 0.0 and **shape** > 0.0.

Pearson Type VI Distribution

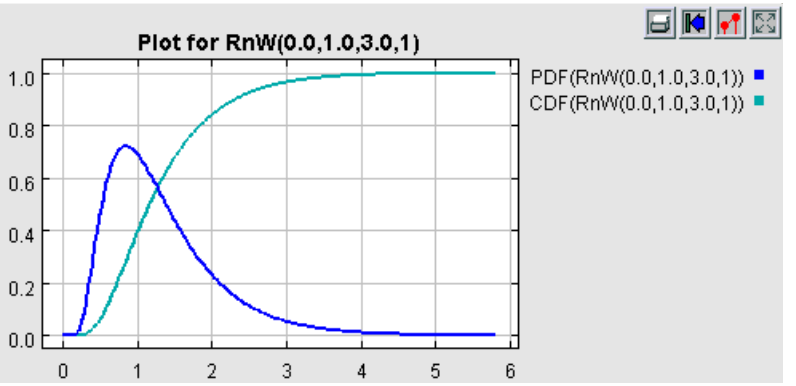


Probability density function and cumulative density function for a Pearson type VI distribution with location = 0, scale = 1, shape1 = 3, and shape2 = 4.

Syntax: PT6(location, scale, shape1, shape2, stream)

The Pearson type VI distribution (continuous) could be used to model the time required to perform some task. The density function can take on a wide variety of shapes because it has two shape parameters **shape1** and **shape2**. The mean and variance are finite only if **shape2** > 2.The Pearson type VI distribution is closely related to the beta distribution - see the book *Simulation Modeling and Analysis* (Third Edition) by Law and Kelton (2000) for details. Parameter restrictions are **scale** > 0.0 and **shape1** > 0.0.

Random Walk Distribution

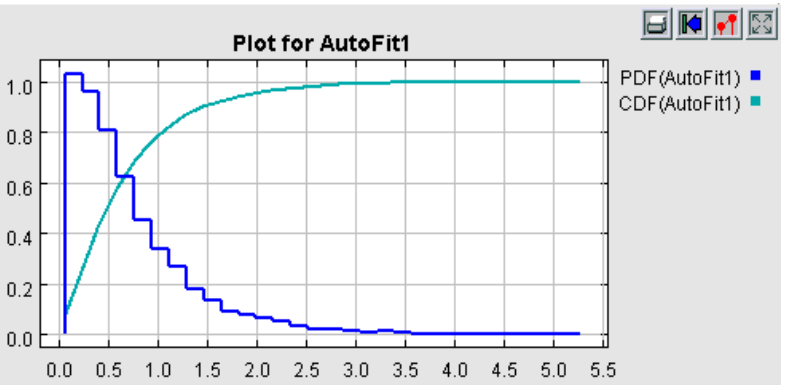


Probability density function and cumulative density function for a random walk distribution with location = 0, scale = 1, and shape = 3.

Syntax: RnW(location, scale, shape, stream)

The random walk distribution (continuous) could be used to model the time required to perform some task. Parameter restrictions are **scale** > 0.0 and **shape** > 0.0.

Empirical Distribution



Empirical distributions are not found on the SIMPROCESS distribution list. An empirical distribution can only be created by an Auto Fit distribution. (See "Auto Fits Distributions" on page 101.) Thus, the name of the Auto Fit distribution appears on the SIMPROCESS distribution list, not the empirical distribution itself.

Empirical distributions consist of pairs of cumulative probability and value and can be discrete or continuous. This is the same format as Tabular Distributions. (See "Tabular Distributions" on page 99.)

APPENDIX E

Statistical Tools Glossary

Absolute Deviation

The average deviation of the data set from the mean. It is computed using the absolute value of the difference between a data point and the mean, rather than squared differences used in computing the variance.

Alpha

The probability that an estimate of a parameter does not contain the true value. In statistics, this is referred to as Type I error.

Alternate Hypothesis

The complement of the null hypothesis.

Cdf

Cumulative distribution function.

χ^2 goodness of fit test

A goodness of fit test that uses an χ^2 statistic to evaluate the goodness of fit. The χ^2 goodness of fit test creates an empirical distribution for the data. The empirical distribution used is a histogram. The height of each bin of the histogram is equal to the number of points in the data set that fall between the lower and upper bounds of the bin. The χ^2 statistic is computed as the sum of squared differences of the values observed for each bin of the histogram to the number of observations expected from the probability distribution over the same range as the bin.

Confidence Interval

An interval that contains the true value of a parameter with a given probability.

Continuous Domain

A domain whose variables can take on any value in an interval (real numbers). Integer domains are sometimes interpreted as continuous domains with the implicit assumption that the integers represent an underlying continuous domain.

Data Set

A vector (or equivalently, an array or column) of data points that are the realization of a random process.

Degrees of Freedom

The number of independent elements in a statistical computation. The degrees of freedom must be known to compute the probability of a test statistic such as the χ^2 statistic.

Dof

Acronym for degrees of freedom.

Enumeration Domain

A domain whose range is the set of elements in the enumeration.

Goodness of fit test

A statistical test used to determine the probability that an observed data set came from a probability distribution. The null hypothesis is that the data set is drawn from the probability distribution. The alternate hypothesis is that the data set is not drawn from the probability distribution. A test statistic is computed to evaluate the hypothesis. If the probability of observing the test statistic is small (less than alpha), the fit is rejected.

IID

Identically and independently distributed. In simulation, identical means that observations are made from a hypothesized distribution of values that does not change over simulated time. Independent means that observations of one replication are not correlated with other observations, i.e., if one observation has a value of X, then the next observation is probably close to X.

Image Editor

An editor that contains graphs, tables, or text for viewing the results of a statistical analysis.

Integer-valued Domain

A domain whose range is the set of integer numbers.

KS

Acronym for Kolmogorov-Smirnov.

KS goodness of fit test

A goodness of fit test that uses the D statistic to evaluate the goodness of fit. The KS goodness of fit test creates an empirical distribution for the data. The empirical distribution assigns a probability of 1/N to each data point where N is number of data points in the data set. The D statistic is computed as the maximum difference between the cumulative distribution function of the empirical distribution and the cumulative distribution function of the probability distribution being tested.

Kurtosis

Characterizes the relative peakedness or flatness of a distribution relative to the normal distribution. A data set with positive kurtosis has a sharper peak than a normal distribution, while a data set with negative kurtosis has a flatter peak than the normal distribution.

Maximum Likelihood Estimate

A statistical technique for estimating the parameters of a hypothesized distribution of a data set.

Mean

Average value of a data set.

MLE

Acronym for maximum likelihood estimate.

Mode

The mode of a probability distribution is the value of X where it takes on its maximum value. If the distribution is multiply-peaked, there may not be a unique mode.

Model Element

A named object in the simulation model that has one or more simulation input variables that can be designated as factors for an experiment. The model elements include Activities, Resources, and Entity types.

Pdf

Probability density function.

Performance Measure.

An output statistic that quantifies some behavior of the model.

Percentiles

In a data set ranked by value of the data points, a percentile refers to the data point at the relative position by rank of the data point in the data set. For example, in a data set of a hundred points, the 75^{th} percentile (75%) point is the data point that is in the 75^{th} position when ranked by value.

Quartile Range

Difference between the 25^{th} percentile value and 75^{th} percentile value of the data set.

Range

Difference between the minimum and maximum values of a data set.

Real-valued Domain

A domain whose range is the set of real numbers.

Residuals

The differences between the actual values observed and the expected values as computed by a statistical test.

Sample Domain

A domain whose range is the set of probability distributions supported by SIMPROCESS.

Skewness

Characterizes the degree of asymmetry of a distribution around its mean. A data set with positive skewness has a long tail to the right of its mean. A data set with negative skewness has a long tail to the left of its mean.

Standard Deviation

Square root of the variance.

Standard Error

A measure of the spread of the data set about the mean. Typically, standard error is the one sigma error about the mean of the data set computed as the standard deviation divided by the square root of the number of data points.

Variance

Variability of data set about the mean.

APPENDIX F

SIMPROCESS System Attributes and Methods

Chapter 10 discussed user defined attributes. SIMPROCESS also includes numerous predefined System Attributes and Methods. Each are listed along with a description. Also, there are examples for several of the System Methods.

System Attributes

This section lists all the SIMPROCESS system attributes in a table.

SIMPROCESS System Attributes

Model Elements	Attribute Name[a]	Get/ Set	Attribute Type	Description
System Level[b]	Model	Get	OBJECT	Reference of the Model being simulated.
	Self	Get	OBJECT	Reference of the Model Element itself.
	Background	Get	BOOLEAN	TRUE if the model is being simulated without the GUI.
	Replication	Get	INTEGER	Current replication number.
Entity Type	Name	Get	STRING	Name of the Entity.
	Priority	Both	INTEGER	Default priority for Entity instances of this type.
	NumberIn	Get	INTEGER	Number of Entity instances of this type currently in the system.
	NumberCreated	Get	INTEGER	Number of Entity instances generated for this type.
	NumberDisposed	Get	INTEGER	Number of disposed Entity instances of this type.
	NumberWaiting	Get	INTEGER	Number of Entity instances of this type waiting for resources
	NumberOnHold	Get	INTEGER	Number of Entity instances of this type holding for condition
	Interrupt	Both	BOOLEAN	Determines whether Entity instances of this type will interrupt the processing of a lower priority Entity.
Entity (instance)	Name	Get	STRING	Name of this Entity.

SIMPROCESS System Attributes

Model Elements	Attribute Name[a]	Get/ Set	Attribute Type	Description
	Activity	Get	OBJECT	Reference of Activity this Entity instance resides in.
	AcceptTime	Get	REAL	Time Entity enters an Activity or Process.
	ActivityTime	Get	REAL	Total time Entity was in an Activity, whether waiting, on hold, or processing. Does not apply to Processes.
	BatchSize	Get	INTEGER	Number of Entity instances in this Entity's batch.
	CreateTime	Get	REAL	Time the Entity instance was created.
	EndWait	Both	BOOLEAN	TRUE if Entity wait for Resources was interrupted by MaxWait time.
	EnterTime	Get	REAL	Time the Entity instance entered the current Activity.
	HasParent	Get	BOOLEAN	TRUE if the Entity instance was created by a Split Activity.
	LastDelay	Get	REAL	Last processing delay time at an Activity.
	MaxWait	Both	REAL	Maximum time Entity will wait for Resource allocation. Default is 0.0 (unlimited).
	NumberIn	Get	INTEGER	Number of Entity instances of the same type currently in the system.
	NumberCreated	Get	INTEGER	Number of Entity instances of the same type has generated.
	NumberDisposed	Get	INTEGER	Number of Entity instances of the same type has disposed.
	NumberWaiting	Get	INTEGER	Number of Entity instances of the same type waiting for resources
	NumberOnHold	Get	INTEGER	Number of Entity instances of the same type holding for condition

SIMPROCESS System Attributes

Model Elements	Attribute Name[a]	Get/ Set	Attribute Type	Description
	Parent	Get	OBJECT	Returns the Parent Entity instance of this Entity instance. An Entity instance only has a Parent when it was created by a Split Activity. The original Entity instance entering the Split Activity is the Parent.
	Priority	Both	INTEGER	Priority of this Entity instance.
	ReleaseTime	Get	REAL	Time Entity is released from an Activity or Process.
	SequenceNum	Get	INTEGER	A unique number given to each Entity as it is created.
	Type	Get	OBJECT	Entity Type reference of this Entity instance.
	Interrupt	Both	BOOLEAN	Determines whether this Entity instance will interrupt the processing of a lower priority Entity.
Resource	Name	Get	STRING	Name of the Resource.
	Activity	Get	OBJECT	Reference of Activity currently trying to assign or free this Resource (if any).
	Capacity	Get	REAL	Resource capacity.
	Entity	Get	OBJECT	Reference of current Entity instance being processed by the Activity trying to assign this Resource (if any).
	LastDowntime	Get	REAL	Duration of most recently initiated downtime.
	NumberWaiting	Get	INTEGER	Number of Entities waiting for this Resource.
	StartDowntime	Get	REAL	Time most recently initiated down-time started.

SIMPROCESS System Attributes

Model Elements	Attribute Name[a]	Get/ Set	Attribute Type	Description
	UnitsBusy	Get	REAL	Number of units of the Resource in busy state.
	UnitsDown	Get	REAL	Number of units of the Resource not available because of the application of a downtime.
	UnitsIdle	Get	REAL	Number of units of the Resource in idle state.
Connector	Name	Get	STRING	Name of the Connector.
	NumberAccepted	Get	INTEGER	Number of Entities so far entered the Connector.
	NumberReleased	Get	INTEGER	Number of Entities exited the Connector.
	NumberIn	Get	INTEGER	Number of Entities currently on the Connector.
	LastDelay	Get	REAL	The value most recently initiated delay.
	NextDelay	Set	REAL	Change the value of the next delay ONLY.
	AllFutureDelays	Set	REAL	Change the value of all future delays henceforth.
Activity's Group I	Name	Get	STRING	Name of the Activity.
	Parent	Get	OBJECT	Reference of this Activity's parent process.
	Entity	Get	OBJECT	Reference of the current Entity.
	Sibling(name: STRING)	Get	OBJECT	It returns the reference to the Activity or process with the specified name in the same hierarchical level.
Activity's Group II	NumberAccepted	Get	INTEGER	Number of Entities so far entered this Activity.

SIMPROCESS System Attributes

Model Elements	Attribute Name[a]	Get/ Set	Attribute Type	Description
	NumberReleased	Get	INTEGER	Number of Entities exited this Activity.
	NumberIn	Get	INTEGER	Number of Entities currently at this Activity.
Activity's Group III	LastDelay	Get	REAL	The value of the most recently initiated delay.
	NextDelay	Set	REAL	Change the value of the next delay ONLY.
	AllFutureDelays	Set	REAL	Change the value of all future delays henceforth.
Assemble	Group I, II, & III			
	Activated-ByNoMatch	Get	BOOLEAN	Checks if the expression is activated by an Entity exiting through the NoMatch Pad.
	ActivatedByTrigger	Get	BOOLEAN	Checks if the expression is activated by an Entity entering from the Trigger Pad.
	AssembleEntity-Type	Both	OBJECT	Type of Entity to create when an Assemble occurs.
	BatchEntities	Both	BOOLEAN	Value for whether to batch component Entities with assembled Entity.
	NumberWaiting	Get	INTEGER	Number of Entities at this activity waiting for resources.
	NumberOnHold	Get	INTEGER	Number of Entities at this activity holding for condition.
Assign	Group I, II, & III			
	NumberWaiting	Get	INTEGER	Number of Entities at this activity waiting for resources
Batch	Group I, II, & III			

SIMPROCESS System Attributes

Model Elements	Attribute Name[a]	Get/ Set	Attribute Type	Description
	BatchEntityType	Both	OBJECT	Type of Entity to create when a Batch occurs.
	MaxBatchSize	Both	INTEGER	Number of Entities to batch.
	MinBatchSize	Both	INTEGER	Number of Entities must be in a batch before it can be released.
	MaxWaitTime	Both	REAL	Time to wait before releasing under-size batch.
	NumberWaiting	Get	INTEGER	Number of Entities at this activity waiting for resources
	NumberOnHold	Get	INTEGER	Number of Entities at this activity holding for condition
Branch	Group I, II, & III			
	BranchName	Set	STRING	Name of the Connector to be taken by the next Entity.
	NumberWaiting	Get	INTEGER	Number of Entities at this activity waiting for resources
Clone	Group I, II, & III			
	NumOutEntities	Both	INTEGER	Number of Entities to output per Con-nector.
	NumberWaiting	Get	INTEGER	Number of Entities at this activity waiting for resources
Delay	Group I, II, & III			
	NumberWaiting	Get	INTEGER	Number of Entities at this activity waiting for resources
Dispose	Group I & II			
	MaxCount	Both	INTEGER	Number of Entities disposed to signal End Simulation event.
	NumberDisposed	Get	INTEGER	Number of Entities so far disposed at this Activity.

SIMPROCESS System Attributes

Model Elements	Attribute Name[a]	Get/ Set	Attribute Type	Description
Free Resource	Group I & II			
Gate	Group I, II, & III			
	ActivatedByTrig-ger	Get	BOOLEAN	Checks if the expression is activated by an Entity entering from the Trig-ger Pad.
	AutoRelCount	Both	INTEGER	Number of Entities for threshold release.
	AutoRelease	Both	BOOLEAN	Whether threshold release is on.
	BatchEntities	Both	BOOLEAN	Value for whether to batch released Entities
	BatchEntityType	Both	OBJECT	Type of Entity to create when a Batch occurs.
	LastRelCount	Get	INTEGER	Number of Entities released in the previous threshold/trigger release.
	TrigNextRel-Count	Both	INTEGER	Value of the trigger release quantity at the next trigger.
	TrigFutureRel-Count	Set	INTEGER	Change the trigger release quantity for all future triggered release hence-forth.
	NumberWaiting	Get	INTEGER	Number of Entities at this activity waiting for resources
	NumberOnHold	Get	INTEGER	Number of Entities at this activity holding for condition
Generate	Group I			
	NumberGener-ated	Get	INTEGER	Number of Entities generated at this Activity.
Get Resource	Group I & II			
	NumberWaiting	Get	INTEGER	Number of Entities at this activity waiting for resources

SIMPROCESS System Attributes

Model Elements	Attribute Name[a]	Get/ Set	Attribute Type	Description
Join	Group I, II, & III			
	BatchEntities	Both	BOOLEAN	Value for whether to batch family members with original Entity
	NumberWaiting	Get	INTEGER	Number of Entities at this activity waiting for resources
	NumberOnHold	Get	INTEGER	Number of Entities at this activity holding for condition
Merge	Group I & II			
Process	Group I & II			
	Child(name : STRING)	Get	OBJECT	For hierarchical processes ONLY. It returns the reference to the child Activity or process with the specified name.
Replenish Resource	Group I & II			
Split	Group I, II, & III			
	NumberWaiting	Get	INTEGER	Number of Entities at this activity waiting for resources
Synchronize	Group I, II, & III			
	NumberWaiting	Get	INTEGER	Number of Entities at this activity waiting for resources
	NumberOnHold	Get	INTEGER	Number of Entities at this activity holding for condition
Transform	Group I, II, & III			
	NumOutEntities	Both	INTEGER	Number of output Entities.
	NumberWaiting	Get	INTEGER	Number of Entities at this activity waiting for resources
	TransformEntity-Type	Both	OBJECT	Type of Entity to create when a Transform occurs.

SIMPROCESS System Attributes

Model Elements	Attribute Name[a]	Get/ Set	Attribute Type	Description
Unbatch	Group I, II, & III			
	NumberWaiting	Get	INTEGER	Number of Entities at this activity waiting for resources
	RetainBatchedEntities	Both	BOOLEAN	Value of Retain Batched Entities
	UnbatchNestedBatches	Both	BOOLEAN	Value of Unbatch Nested Batches

a. System attributes' names must be input as shown. They are case sensitive.
b. Attributes in this category can be referenced in any expression.

SIMPROCESS System Methods

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
ABS	X: INTEGER or REAL	INTEGER or REAL	Returns the absolute value of X. The type (INTEGER or REAL) of the returned value will be the same type as the argument.
ActivateGenerate	Generate Name: STRING	NONE	If not already started, starts the generation of Entities by the specified generate activity.
ACOS	X: REAL	REAL	Returns the ACOSine of X.
AddPlotLegend	Plot: OJBECT Dataset: INTEGER Label: STRING Color (Optional): STRING	NONE	Adds a legend to a plot created through expressions (CreatePlot system method). Datasets are numbered beginning with 0. The Label of the legend must be specified. Specifying the Color is optional.
Alert	MasterEditor[b], Message: STRING	NONE	Display a message in the **Alert** dialog and wait for the user to close this dialog.
ASIN	X: REAL	REAL	Returns the ASine of X.
ATAN	X: REAL	REAL	Returns the ATANgent of X.
ATAN2	Y: REAL, X: REAL	REAL	Returns the ATANgent of X and Y.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
Attribute	AttributeName: STRING	OBJECT	Returns the reference to the specified Attribute. AttributeName follows the same convention as specifying Attributes in Expressions. That is, qualifiers (Entity, Entity.Type, and Model) might be required before the Attribute name (such as Entity.StartTime). The object owning the Attribute can be specified by including a colon (:) and the name of the object in AttributeName. For example Attribute("Time:Dispose1") would return the Attribute named Time from the Activity Dispose1. The object reference can be an Entity Type, Resource, or Activity. Note that using the object name is the only way to retrieve Resource Attributes.
Beep	MasterEditor[b]	NONE	Makes a beep sound.
BINARYTOINT	BinaryValue: STRING	INTEGER	Returns the integer value of a binary string.
CEIL	X: REAL	INTEGER	Returns the smallest integer not less than X.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
ChangeColor	ActName: STRING, Color: STRING	NONE	Changes the color of the specified Activity. Entity references are no longer allowed. The keywords Self, Activity, and Parent or the name of an activity is allowed for ActName. Note that a keyword must be input as a STRING (such as "Self"). The Color can be any of the 65 colors listed in the SIMPROCESS Color Table at the end of this appendix. To clear a color setting enter "Clear" for the Color.
ClearMap	Map: OBJECT	NONE	Clears all values from the specified map.
ClearPlot	Plot: OBJECT	NONE	Clears the specified plot.
CloseDatabase	Database Connection: OBJECT	NONE	Closes the specified database connection.
CloseFile	File Stream: OBJECT	NONE	Closes the specified file.
CloseSpreadsheet	File Stream: OBJECT	NONE	Closes the specified spreadsheet file.
Confirm	MasterEditor[b], Message: STRING	BOOLEAN	Displays a message in the **Confirm** dialog and waits for the user to respond; **OK** returns TRUE, **CANCEL** returns FALSE.
Connector	ConnectorName: STRING	OBJECT	Returns the reference to the specified Connector.
COS	X: REAL	REAL	Returns the COSine of X.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
CreateArray	Type: STRING Dimension1: INTEGER Dimension2: INTEGER DimensionN: INTEGER	OBJECT	Returns an array of the specified type (“REAL”, “INTEGER”, “BOOLEAN”, “STRING”, or “ANYOBJ”) with the specified dimensions. For example, CreateArray(“REAL”, 2, 2), returns a 2 x 2 array for REAL numbers. Arrays of type REAL and INTEGER are initialized to zero. Arrays of type BOOLEAN are initialized to FALSE. Arrays of type STRING or ANYOBJ are not initialized, thus, attempting to retrieve a value from an array element that has no value will result in an error.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
CreateAttribute	Name: STRING; Type: STRING; Owner: STRING; Mode: STRING; DefaultValue: INTEGER, REAL, BOOLEAN, or STRING ArraySize (Optional): INTEGER DoNotReset (Optional): BOOLEAN StatType (Optional): STRING	NONE	Creates an Attribute. This method can only be used in the **`Start Run`** Expression (**Define/ Model Expressions**). Name should be a unique name that contains no spaces or special characters. An error will occur if an Attribute with the same Name and same Type already exists. Allowable Type values are Entity, Entity.Type, Resource, Activity, or Model. Owner should either be Global or the name of the Attribute owner. The Attribute owner can be an Entity Type, Resource, or Activity. Mode can be INTEGER, REAL, BOOLEAN, STRING, or OBJECT. The DefaultValue should match the designated Mode. If OBJECT is the Mode, "Null" should be entered for the DefaultValue. The remaining parameters are optional. They can be included in any order and not all have to be used. ArraySize sets the array dimension of the Attribute. A value of 0 indicates that the Attribute will not be an array Attribute. If DoNotReset is TRUE, the Attribute will not be reset between replications. This parameter only applies to global Attributes. It will be ignored for local Attributes. StatType can be Observation, TimeWeighted, or None. This parameter is ignored for Entity Attributes.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
CreateEntityType	Name: STRING Icon: STRING Priority: INTEGER Preempt: BOOLEAN Entity Stats: BOOLEAN	NONE	Creates an Entity Type. This method can only be used in the **`Start Run`** Expression (**Define/ Model Expressions**). An error will occur if an Entity Type with the same name already exists in the model. “Default” can be used for the Icon parameter. Priority must be between 1 and 100 inclusive. Preempt sets the “Premept Lower Priority Entities” property, and Entity Stats sets the “Collect Entity Statistics” property.
CreateMap	Type: STRING	OBJECT	Returns a map of the specified type ("REAL", "INTEGER", "BOOLEAN", "STRING", or "ANYOBJ"). Maps are not initialized to default values.
CreatePlot	Type: STRING Title: STRING X Axis Label (Optional): STRING Y Axis Label (Optional): STRING	OBJECT	Creates plot and returns the Plot object to an Attribute of type Object. The Type can be Trace or Histogram. The Type and the Title are required. The axis labels are optional, but to have a Y Axis Label, there must be an X Axis Label. AddPlotLegend is used to add legends to the Plot. PlotValue plots a new point. DisplayPlot causes the plot to be visible, and ClearPlot clears the plot of all data.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
CreateResource	Name: STRING Units: REAL Fractional: BOOLEAN Consumable: BOOLEAN Resource Stats: BOOLEAN Resource by Activity Stats: BOOLEAN	NONE	Creates a Resource. This method can only be used in the **`Start Run`** Expression (**Define/Model Expressions**). An error will occur if a Resource with the same name already exists in the model.
DateTime	None	STRING	Returns the current date and time of the simulation in MM/DD/YYYY HH:MM:SS:MSEC:USEC:NSEC format.
DayOfWeek	None	STRING	Returns the current day of the week (Monday, Tuesday, etc.).
DecreaseCapacity	Resource Name: STRING Units: INTEGER or REAL	NONE	Decreases the capacity of a Resource by the units specified.
DisplayPlot	Plot: OBJECT	NONE	Displays the specified plot. A Plot can also be displayed by using the Menu (**Report/Display Real-Time Plots**) or by using the **Display Plots** button on the tool bar.
DrawIntegerSample	Statistical Distribution: STRING	INTEGER	Draws a sample of type integer from the specified statistical distribution.
DrawRealSample	Statistical Distribution: STRING	REAL	Draws a sample of type real from the specified statistical distribution.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
ElapsedTime	Units (Optional): STRING Start: STRING End: STRING	REAL	Returns the amount of time between the Start value and End value. The Units is optional and can be any valid time unit ("Seconds," "Minutes," etc.). If omitted, the value returned is in the units set by **Simulation Time Unit** in **Run Settings**. Start and End use the format MM/DD/YYYY HH:MM:SS:MSEC:USEC:NSEC. The formats MM/DD/YY and YYYY-MM-DD can also be used for the date portion of Start and End. The **DateTime** function can be used for Start or End.
EntityExists	Gate: OBJECT SequenceNum: INTEGER	INTEGER	Checks the specified Gate activity (obtained using the Gate System Method) for an Entity with the specified SequenceNum. Returns the position number of the Entity in the Gate. This can be used with the GetEntity System Method to return a reference to the Entity. If the Entity is not being held in the Gate activity, 0 is returned.
EXP	X: REAL	REAL	Returns e raised to the power of X.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
ExternalCall	Class Name: STRING Method Name: STRING Method Parameters (as required by external method): INTEGER, REAL, STRING, BOOLEAN, OBJECT	BOOLEAN, REAL, INTEGER, STRING, or OBJECT	Executes a method of an external Java class. Assumes the class is in the appropriate package structure in a **`classes`** directory within the model's directory or in a properly constructed jar file in the same location. (See "SIMPROCESS and External Java Classes," beginning on page 602 for other options.) Errors in the calls will result in an aborted simulation. Note: To use this call you must have purchased the External Application Interface plug-in license from CACI.
FireTrigger	Activity Name: STRING	NONE	Fires the trigger of the specified Gate or Assemble Activity.
FLOAT	Number: INTEGER	REAL	Converts the argument to REAL.
FLOOR	X: REAL	INTEGER	Returns the largest integer not greater than X.
FreeResource	Resource Name: STRING Tag (Optional): STRING Consume (Optional): BOOLEAN	NONE	Creates a free Resource request for an Activity.
Function	Function Name: STRING	REAL	Returns the value of a User-defined Function.
Gate	Gate Name: STRING	OBJECT	Returns a reference to the specified Gate activity.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
GenerateEntity	Generate Name: STRING Entity Name (Optional): STRING Quantity (Optional): INTEGER Time (Optional): REAL	NONE	Generates Entities from the specified Generate Activity. If Entity Name is not specified, the default defined for Entity Type in the specified Generate Activity is used. If Quantity is not specified, the default Quantity in the designated Generate Activity is used. If Time is not specified, the action occurs at the current simulation time. Time is in the **Simulation Time Units** set in the **Run Settings**. Each of the optional parameters can be specified without including any of the other optional parameters.
GetActivityStatistic	Activity Name: STRING Statistic: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the requested **Activity Name** statistic. **Statistic** is one of the statistics types for Activities listed in the Labels column of the table in Appendix H. (See "Statistic Types" on page 586.) **Value Type** is either "Avg," "StDev," "Min," "Max," "Count," or "Run-Length." A **Replication** of -1 returns the average of replications, and a **Replication** of -2 returns the sum of replications.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
GetActivityByEntityStatistic	Activity Name: STRING Entity Name: STRING Statistic: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the requested **Activity Name** and **Entity Name** statistic. **Statistic** is one of the statistics types for Activities listed in the Labels column of the table in Appendix H. (See "Statistic Types" on page 586.) **Value Type** is either "Avg," "StDev," "Min," "Max," "Count," or "RunLength." The value for **Replication** cannot be larger than the current replication simulating. A **Replication** of -1 returns the average of replications, and a **Replication** of -2 returns the sum of replications.
GetArrayValue	Array: OBJECT Index1: INTEGER Index2: INTEGER IndexN: INTEGER	REAL, INTEGER, BOOLEAN, STRING, or OBJECT	Returns from the designated array the value at the specified indices. Note that the array indices are zero based. Attempting to get a value from an element of a STRING or ANYOBJ array that has had no value assigned will result in an error.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
GetAttributeStatistic	Attribute Name: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the requested **Attribute Name**. **Attribute Name** must be unique among the attributes that are being statistically monitored. **Value Type** is either "Avg," "StDev," "Min," "Max," "Count," or "RunLength." A **Replication** of -1 returns the average of replications, and a **Replication** of -2 returns the sum of replications.
GetConnectorStatistic	Connector Name: STRING Statistic: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the requested **Connector Name** statistic. **Statistic** is one of the statistics types for Connectors listed in the Labels column of the table in Appendix H. (See "Statistic Types" on page 586.) **Value Type** is either "Avg," "StDev," "Min," "Max," "Count," or "RunLength." A **Replication** of -1 returns the average of replications, and a **Replication** of -2 returns the sum of replications.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
GetConnectorByEntityStatistic	Connector Name: STRING Entity Name: STRING Statistic: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the requested **Connector Name** and **Entity Name** statistic. **Statistic** is one of the statistics types for Connectors listed in the Labels column of the table in Appendix H. (See "Statistic Types" on page 586.) **Value Type** is either "Avg," "StDev," "Min," "Max," "Count," or "RunLength." The value for **Replication** cannot be larger than the current replication simulating. A **Replication** of -1 returns the average of replications, and a **Replication** of -2 returns the sum of replications.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
GetCostStatistic	Period Name: STRING Cost Object 1: STRING Cost Object 2: STRING Cost Type: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the requested **Period Name**, **Cost Object 1**, and **Cost Object 2**. **Cost Object 1** can be the name of a Resource or an Activity. **Cost Object 2** can be the name of an Activity or an Entity. Thus, the combination of **Cost Object 1** and **Cost Object 2** can be "Resource and Entity," "Resource and Activity," or "Activity and Entity." **Cost Type** options are "Capacity" or "Absorption". **Value Type** is either "Avg," "StDev," "Min," or "Max" for **Replication** -1. If **Replication** is 1 or greater, the maximum value is returned no matter what is entered for **Value Type**. A **Replication** of -1 returns the average of replications, and a **Replication** of -2 returns the sum of replications.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
GetEntity	Gate, Resource, or Entity: OBJECT Index: INTEGER	OBJECT	Returns a reference to the Entity being held at the specified Gate Activity, waiting for the specified Resource, or being held as part of the specified Entity's batch. Index indicates the position in the appropriate queue and must be greater than or equal to 1 and less than or equal to the number of Entities being held at the Gate activity (obtained by using Gate System Attribute NumberOnHold), less than or equal to the number of Entities waiting for the Resource (obtained by using Resource System Attribute NumberWaiting), or less than or equal to the number of Entities in the batch (obtained by using the Batch System Attribute BatchSize).
GetEntityStatistic	Entity Name: STRING Statistic: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the requested **Entity Name** statistic. **Statistic** is one of the statistics types for Entities listed in the Labels column of the table in Appendix H. (See "Statistic Types" on page 586.) **Value Type** is either "Avg," "StDev," "Min," "Max," "Count," or "RunLength." A **Replication** of -1 returns the average of replications, and a **Replication** of -2 returns the sum of replications.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
GetFromMap	Map: ANYOBJ Key: INTEGER, REAL, BOOLEAN, STRING, ANYOBJ	INTEGER, REAL, BOOLEAN, STRING, ANYOBJ	Returns from the designated map the value referenced by the specified key.
GetMapKey	Map: ANYOBJ Index: INTEGER;	INTEGER, REAL, BOOLEAN, STRING, ANYOBJ	Returns from the designated map the key specified by the index.
GetMapSize	Map: ANYOBJ	INTEGER	Returns the number of objects in the specified map.
GetNext	Result Set Name: STRING	BOOLEAN	Used to advance to the next row of a Result Set. Returns TRUE if the Result Set has more values.
GetResource	Resource Name: STRING Units: STRING, INTEGER, or REAL Tag (Optional): STRING	NONE	Creates a get Resource request for an Activity.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
GetResourceStatistic	Resource Name: STRING Statistic: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the requested **Resource Name** statistic. **Statistic** is one of the statistics types for Resources listed in the Labels column of the table in Appendix H. (See "Statistic Types" on page 586.) **Value Type** is either "Avg," "StDev," "Min," "Max," "Count," or "Run-Length." A **Replication** of -1 returns the average of replications, and a **Replication** of -2 returns the sum of replications.
GetResourceByActivityStatistic	Resource Name: STRING ActivityName: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the requested **Resource Name** and **Activity Name** statistic. **Value Type** is either "Avg," "StDev," "Min," "Max," "Count," or "Run-Length." A **Replication** of -1 returns the average of replications, and a **Replication** of -2 returns the sum of replications.
GetResult	Result Set Name: STRING Database Field: STRING	INTEGER, REAL, BOOLEAN, STRING	Returns a value from a Result Set. Type of value returned is dependent on the type of values in the requested field of the Result Set.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
GetTimeStampStatistic	Start Key: STRING StopKey: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the Time Stamp with **Start Key** and **Stop Key**. **Value Type** is either "Avg," "StDev," "Min," "Max," "Count," or "RunLength." A **Replication** of -1 returns the average of replications, and a Replication of -2 returns the sum of replications.
GetTotalCostStatistic	Name: STRING Cost Type: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the total cost for the requested Resource, Entity, or Activity **Name**. If **Name** is "Total," then the total cost of all Resources is returned. **Cost Type** is either "Capacity" or "Absorption." **Value Type** is either "Avg," "StDev," "Min," or "Max" for **Replication** -1. If **Replication** is 1 or greater, the maximum value is returned no matter what is entered for **Value Type**. A **Replication** of -1 returns the average of replications, and a **Replication** of -2 returns the sum of replications.
HALT	Message (Optional): STRING	NONE	If used with no parameters, it ends the current replication and simulation continues with next replication. If parameters are used, the simulation is stopped with an error condition. A dialog appears that contains the contents of the parameter.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
IncreaseCapacity	Resource Name: STRING Units: INTEGER or REAL	NONE	Increases the capacity of a Resource by the units specified.
INTTOBINARY	number: INTEGER	STRING	Converts a non-negative integer number to a binary string.
INTTOSTR	number: INTEGER	STRING	Converts an integer number to a string.
LN	X: REAL	REAL	Returns the Natural Log of X.
LOG10	X: REAL	REAL	Returns the base 10 Log of X.
MAXOF	list of numbers: REAL/INTEGER (all the numbers in list must be of the same type)	REAL or INTEGER	Returns the maximum number in the given list. Return type is the same as the input list.
MINOF	list of numbers: REAL/INTEGER (all the numbers in list must be of the same type)	REAL or INTEGER	Returns the minimum number in the given list. Return type is the same as the input list.
OpenDatabase	Database DSN: STRING or Properties File: STRING UserName (Optional): STRING Password (Optional): STRING	OBJECT	Creates a connection to the database specified by the DSN. The DSN for the database is specified in the ODBC control panel in Windows. The UserName and Password are optional. However, if UserName is used, Password must also be used. When not using Windows, the Properties File is the name of the file that specifies the URL and protocol to use.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
OpenFile	Mode: STRING File Name: STRING	OBJECT	Open the specified file and return the file stream object. Mode can be "input" or "output." The File Name String can contain path names if the user wants to explicitly tell SIMPROCESS where the file resides. If path separators (e.g., \ in Windows, / on other systems) are used, the program assumes the user is providing a complete and valid file path. If no path separators are detected in the file name, the Model's folder is where the files will reside. Note that double backslashes (\\) must be used in Windows file paths instead of a single backslash.
OpenSpreadsheet	Mode: STRING File Name: STRING	OBJECT	Open the specified spreadsheet file and return the file stream object. Mode can be "input" or "output." The File Name String can contain path names if the user wants to explicitly tell SIMPROCESS where the file resides. If path separators (e.g., / on other systems or \ in Windows) are used, the program assumes the user is providing a complete and valid file path. If no path separators are detected in the file name, the Model's folder is where the files will reside. Note that double backslashes (\\) must be used in file paths instead of a single backslash.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
OUTPUT	Takes zero or more arguments separated by commas. Type can be REAL, BOOLEAN, INTEGER, or STRING	NONE	Display the specified arguments in the **Output** dialog. Functions (including nested functions) that result in any of the argument types can be used in the OUTPUT statement.
PlotValue	Plot: OBJECT Dataset: INTEGER X Value: INTEGER or REAL Y Value (Trace only): INTEGER or REAL	NONE	Adds a data point to the specified Dataset of the plot. Datasets are numbered beginning with 0. Trace plots require an X Value and a Y Value. Histogram plots only use the X Value.
POSITION	String1: STRING String2: STRING	INTEGER	This method returns the starting position of String2 in String1. If String2 is not completely contained in String1, it returns 0.
POWER	X: REAL, Y REAL	REAL	Returns X raised to the power of Y.
PutInMap	Map: ANYOBJ Key: INTEGER, REAL, BOOLEAN, STRING, ANYOBJ Value: INTEGER, REAL, BOOLEAN, STRING, ANYOBJ	NONE	Places the value in the specified map using the key as reference.
READ	INTEGER, REAL, STRING, or BOOLEAN	INTEGER, REAL, STRING, or BOOLEAN.	Reads a single variable into an identifier from a dialog prompt. The name of the identifier will be presented in the dialog for the user, and the value entered will be validated (i.e., INTEGER type must be an integer value).

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
ReadFromDatabase	Database Connection: OBJECT Result Set Name: STRING SQL Statement: STRING	NONE	Reads values based on the SQL Statement from the database specified by the connection. The values are placed in a Result Set with the given Result Set Name. The Result Set Name should be unique for each ReadFromDatabase unless a Result Set is to be replaced.
ReadFromFile	File Stream: OBJECT List of variables	NONE	Read values for the listed variables from the input file associated with the specified File Stream.
ReadFromSpreadsheet	File Stream: OBJECT Sheet Name: STRING Row: INTEGER Column: INTEGER Variable: STRING, INTEGER, REAL, or BOOLEAN	NONE	Read a value from the specified sheet, row, and column of the input spreadsheet file associated with the specified File Stream. The value is assigned to Variable.
REALTOSTR	number: REAL precision: INTEGER (Optional)	STRING	Converts a real number to a string. If a precision is specified, the number is rounded to the specified precision. Trailing zeroes are added if the decimal part of the number is less than the specified precision.
ReleaseEntity	Gate: OBJECT SequenceNum: INTEGER	BOOLEAN	Causes the release of the Entity with the specified SequenceNum from the specified Gate. (The Gate parameter is obtained using the Gate System Method.) Returns TRUE if the Entity was released, FALSE otherwise.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
RemoteCall	Server URL: STRING Server Name: STRING Method Name: STRING Method Parameters (as required by remote method): INTEGER, REAL, STRING, BOOLEAN	BOOLEAN	Executes a method of a remote application. Assumes a Java RMI server has been registered with the objects and methods being called. Errors in the calls will result in an aborted simulation. Note: To use this call you must have purchased the External Application Interface plug-in license from CACI.
RemoveFromMap	Map: ANYOBJ Key: INTEGER, REAL, BOOLEAN, STRING, ANYOBJ	INTEGER, REAL, BOOLEAN, STRING, ANYOBJ	Removes and returns from the designated map the value referenced by the specified key.
REPLACE	String1: STRING position1, position2: INTEGER String2: STRING	STRING	Returns a string that is in String1 with part of String1 from position 1 to position 2 replaced with String2.
Resource	ResourceName: STRING	OBJECT	Returns the reference to the specified Resource.
ROUND	number: REAL	INTEGER	Rounds the argument and returns the closest integer value.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
SetActivityExpression	ActivityName: STRING ExpressionType: STRING Expression: STRING	NONE	Applies SIMPROCESS Expression code in the specified Expression parameter to the specified Activity. This method can only be used in the **`Start Run`** Expression (**Define/Model Expressions**). ExpressionType is case sensitive must be valid for the type of Activity specified. The Expression parameter should be the complete Expression code in a single STRING or the complete file name with no path of the file that contains the Expression code. If the Expression parameter is a file, the file must located in the model's directory.
SetArrayValue	Array: OBJECT Index1: INTEGER Index2: INTEGER IndexN: INTEGER Value: REAL, INTEGER, BOOLEAN, STRING, or OBJECT	NONE	Sets the value at the specified indices of the specified array. Note that the indices are zero based.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
SetEntityExpression	EntityTypeName: STRING ExpressionType: STRING Expression: STRING	NONE	Applies SIMPROCESS Expression code in the specified Expression parameter to the specified Entity Type. This method can only be used in the **`Start Run`** Expression (**Define/Model Expressions**). ExpressionType is case sensitive and must be a valid Entity Instance Expression type (**`Initialize Entity`**, **`Accept Entity`**, **`Interrupt Processing`**, **`Resume Processing`**, **`Release Entity`**, or **`Dispose of Entity`**). The Expression parameter should be the complete Expression code in a single STRING or the complete file name with no path of the file that contains the Expression code. If the Expression parameter is a file, the file must located in the model's directory.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
SetEntityTypeExpression	EntityTypeName: STRING ExpressionType: STRING Expression: STRING	NONE	Applies SIMPROCESS Expression code in the specified Expression parameter to the specified Entity Type. This method can only be used in the **`Start Run`** Expression (**Define/Model Expressions**). ExpressionType is case sensitive and must be a valid Entity Type Expression type (**`Start Simulation`**, **`Start Trial`**, **`Initialize Entity`**, **`Dispose of Entity`**, **`End Trial`**, or **`End Simulation`**). The Expression parameter should be the complete Expression code in a single STRING or the complete file name with no path of the file that contains the Expression code. If the Expression parameter is a file, the file must located in the model's directory.
SetResourceCost	ResourceName: STRING Cost: REAL CostType: STRING TimeUnit: STRING	NONE	Sets one of the costs of the specified Resource. CostType can be PerEntity, PerUnit, PerTimeUnit, or Fixed. If PerTimeUnit is the CostType, then TimeUnit must be one of the valid SIMPROCESS time units (Hours, Minutes, etc.). If Fixed is the CostType, then the TimeUnit must be Weekly, Montly, Quarterly, Half-Yearly, or Yearly. TimeUnit is not required if the CostType is PerEntity or PerUnit. Note that if the Resource is consumable, then only PerEntity and PerUnit are valid CostTypes.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
SetResourceDowntime	ResourceName: STRING DowntimeName: STRING	NONE	Applies a global Resource Downtime (**Define/Resource Downtimes**) to the specified Resource. This method can only be used in the **`Start Run`** Expression (**Define/Model Expressions**).
SetResourceExpression	ResourceName: STRING ExpressionType: STRING Expression: STRING	NONE	Applies SIMPROCESS Expression code in the specified Expression parameter to the specified Resource. This method can only be used in the **`Start Run`** Expression (**Define/Model Expressions**). ExpressionType is case sensitive and must be a valid Resource Expression type (**`Start Simulation`**, **`Start Trial`**, **`Get Resource`**, **`Free Resource`**, **`Start Downtime`**, **`End Downtime`**, **`End Trial`**, or **`End Simulation`**). The Expression parameter should be the complete Expression code in a single STRING or the complete file name with no path of the file that contains the Expression code. If the Expression parameter is a file, the file must located in the model's directory.
ShowSystemAttributes[c]	None	NONE	Display all the System-Defined Attributes of the calling element and any related elements that are within scope (i.e., if this function is called on the Activity expression, then the system attributes for any Entity or Resource elements will also be included) in the **Output** dialog.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
ShowUserAttributes[c]	None	NONE	Display all the User-Defined Attributes evaluated for the calling elements and any related elements that are within scope (i.e., if this function is called on the Activity expression, then the user-defined attributes for any Entity or Resource elements will also be included) in the **Output** dialog.
SimTime	Timeunit (Optional): STRING Valid time units are - Years, Months, Weeks, Days, Hours, Minutes, Seconds, Milliseconds, Microseconds, Nanoseconds. Time unit strings are case sensitive.	REAL	Return current simulation time in time units specified. If no parameter is provided, time unit defaults to the Simulation Time Unit set in the Run Settings.
SIN	X: REAL	REAL	Returns the Sine of X.
SOAPCall	ContinueOnError: BOOLEAN or STRING Endpoint URL: STRING Service Name: STRING Service Port Type Name: STRING Body namespace URI: STRING Method namespace URI: STRING SOAP action URI: STRING Method to invoke: STRING Parameters (Optional): Parameter Name : STRING Parameter Value: STRING, BOOLEAN, INTEGER, REAL	STRING	Invokes methods (or operations) on Web services. See "Method SOAPCall" on page 571 for more information.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
SQRT	X: REAL	REAL	Returns the square root of X.
STATUS	Same as OUTPUT	NONE	Display the specified arguments in status bar.
StopSimulation	NONE	NONE	Completely stops a running simulation. Any remaining replications are not simulated.
STRLEN	inString: STRING	INTEGER	Returns the length of the string, inString.
STRTOINT	inString: STRING	INTEGER	Converts a string consisting only of numbers with no decimal in the string to an integer.
STRTOREAL	inString: STRING	REAL	Converts a string of numbers including a decimal to a real.
SUBSTR	position1, position2: INTEGER String: STRING	STRING	Returns the substring of String from position1 to position2, inclusive.
SystemTime	None	REAL	Returns the current system time in milliseconds as the difference between the current time and midnight, 1 Jan 1970 UTC.
TAN	X: REAL	REAL	Returns the TANgent of X.
TimeOfDay	Timeunit (Optional): STRING Valid time units are - Years, Months, Weeks, Days, Hours, Minutes, Seconds, Milliseconds, Microseconds, Nanoseconds. Time unit strings are case sensitive.	REAL	Returns the current time of day in the requested time unit. If no parameter is provided, time unit defaults to the Simulation Time Unit set in the Run Settings.
TRUNC	number: REAL	INTEGER	Returns the integer part of the number

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
UpdateDashboardLabel	Dashboard Name: STRING Host or IP Address: STRING Port: INTEGER TextLabel Name: STRING Value: INTEGER, REAL, STRING or BOOLEAN	NONE	Update the specified TextLabel with the given value.
UpdateDynamicLabel	MasterEditor[b] Label Name: STRING Label ID: INTEGER Font Color: STRING Value: Same as Label's Mode	NONE	Update the specified dynamic label with the given value.
WriteToDatabase	Database Connection: OBJECT SQL Statement: STRING	NONE	Used to modify tables of the database specified by the connection. The SQL Statement should be of type INSERT, DELETE, or UPDATE.
WriteToFile	File Stream: OBJECT list of variables	NONE	Write the values of the listed variables to the output file specified by the File Stream.
WriteToSpreadsheet	File Stream: OBJECT Sheet Name: STRING Row: INTEGER Column: INTEGER Variable: STRING, REAL, INTEGER, or BOOLEAN	NONE	Writes the value of Variable to the specified sheet, row, and column of the output spreadsheet file specified by the File Stream.

a. System methods' names must be input as shown. They are case sensitive.
b. This argument (i.e., MasterEditor) must be the first argument inside the parentheses of this method. It is required by the method and must be input as shown. It is case sensitive.
c. Since this method does not require any argument, do not include empty parentheses when using this method.

System Method Examples

Many of the System Methods described here are demonstrated with models in the **ExpressionDemos** directory. Included in that directory is *SIMPROCESS Expression Demo Models*, which describes each model. If this directory is not part of the **SIMPROCESS/models** directory, it can be downloaded at www.simprocess.com.

Method Alert and Beep:

For example, to display a message and sound alarm when an Entity enters an Activity, put the following lines in the Activity's **Accept Entity** event:

```
Beep(MasterEditor);
Alert(MasterEditor, "Press OK to continue!");
```

Method Confirm, DrawRealSample, MINOF, MAXOF, and REALTOSTR:

This example demonstrates the syntax and usage of the listed methods. It draws a number from a Uniform distribution whose minimum and maximum parameters are results from an Exponential distribution with a mean of 30. The result is displayed in a message box with **OK** and **Cancel** buttons. Pressing **OK** will continue this process again, while **Cancel** will end the process.

```
fContinue : BOOLEAN;
value1, value2, maxval, minval : REAL;

fContinue := TRUE;
WHILE fContinue
value1 := DrawRealSample("Exp(30.0)");
value2 := DrawRealSample("Exp(30.0)");
maxval := MAXOF(value1, value2);
minval := MINOF(value1, value2);
value1 := DrawRealSample("Uni("+REALTOSTR(minval)+"," +REAL-
   TOSTR(maxval)+")");
Beep(MasterEditor);
fContinue := Confirm(MasterEditor, "The value is "+ REAL-
   TOSTR(value1));
END WHILE;
```

Method ChangeColor:

This method changes the color of a non-bitmap icon. Currently, Activity icon "RectangleIcon," and Process icon "DefaultIcon" can change color. The "SIMPROCESS Color Table," beginning on page 576 contains the 65 colors available in SIMPROCESS. The name of an Activity or Process can be specified, or "Self", "Parent", or "Activity" can be used to designate the Activity or Process. Note that in earlier versions of SIMPROCESS (pre 4.1), "Self", "Parent", and "Activity" did not require quotes. Earlier version models using those keywords must be modified to include quotes for use with SIMPROCESS 4.1 or later versions. If an Activity or Process name is used, SIMPROCESS will attempt to change the color of every Activity or Process that matches the input name. To clear a color setting, enter "Clear" for the color.

The following changes the color of the Activity Delay4 to Red.

```
ChangeColor("Delay4", "Red");
```

The following changes the color of the current Activity or Process to Blue.

```
ChangeColor("Self", "Blue");
```

The following changes the color of the parent Process of the current Activity or Process to Yellow.

```
ChangeColor("Parent", "Yellow");
```

The following clears the color setting of the Activity.

```
ChangeColor("Sales Process", "Clear");
```

The ability to change colors of Entities is no longer supported. For example, the following code will now produce an error.

```
ChangeColor(Entity, "Brown");
```

To change the color of the Activity icon to green if there is no Entity in it, in the Activity's **`Release Entity`** event add:

```
IF (NumberIn = 0)
   ChangeColor("Self", "Green");
END IF;
```

Method ShowSystemAttributes and ShowUserAttributes:

These methods display all the system-defined and user-defined attributes with their current values of the calling element in the standard output window. For example, to display the system-defined attributes of an Activity when an Entity enters, in the Activity's **Accept Entity** event put:

```
ShowSystemAttributes;
```

All the system-defined attributes and values are listed in the standard output window. In addition, any related elements' system attributes or user-defined attributes will be listed in the output window as well. For example, if the ShowUserAttributes method is called from the expression script in an Activity event (such as Accept Entity), the Entity that is within scope will also have its user-defined attributes listed. The same goes for Resources being assigned.

Model level user-defined attributes are listed no matter what elements are within scope.

Method SimTime:

This method returns the current simulation time in hours unless a time unit parameter is provided. The return value is **REAL** type. For example:

```
Entity.StartTime := SimTime; { StartTime is a REAL global
   Entity instance attribute of type REAL. }
```

The allowable time units are provided as a string parameter and are case sensitive. The allowable time units are: Years, Months, Weeks, Days, Hours, Minutes, Seconds, Milliseconds, Microseconds, Nanoseconds. An example using the time units is as follows:

```
Mytimeunit : STRING;
Mytimeunit:="Weeks";
OUTPUT("My time unit in weeks = ",
    SimTime(Mytimeunit);
OUTPUT("My time unit in months = ",
    SimTime("Months");
```

Method OUTPUT and STATUS:

To display a message in the standard output window:

```
OUTPUT("Number of orders currently held in Gate10 is : ", Num-
   berIn);

realnum : REAL;

OUTPUT("The String value of realnum = ",

   REALTOSTR(realnum));
```

Or, to display it in the status bar:

```
STATUS("Number of orders currently held in Gate10 is : ", Num-
   berIn);
```

where the expressions above are placed on the Activity, Gate10.

Method UpdateDashboardLabel:

To use this method, you need to assign a Dashboard to your model which contains a TextLabel. To assign Dashboards, refer to "Assigning Dashboards," beginning on page 442.

Five arguments are required for this method. The first is **`Dashboard Name`**. This is the name used when you assigned the Dashboard to your model. You may also use the name of the Dashboard's file (without any path and without the ".spd" extension), although this is not recommended since it negatively impacts performance. The second argument is the **`Host or IP Address`** where a Dashboard Server is expected to be receiving messages for the assigned Dashboard. This value must match the one entered when the Dashboard was assigned. It is important to note that SIMPROCESS compares the values and not their meanings. While **`localhost`** and **`127.0.0.1`** refer to the same system (i.e., they have the same meaning), they are not the same values to SIMPROCESS. The third argument is the **`port`** on which a Dashboard Server is expected to be receiving messages for the assigned Dashboard. This value must also match the one entered when the Dashboard was assigned. The fourth argument is the name of a Graph on the assigned Dashboard of type TextLabel. The name is an uneditable field displayed on the properties dialog for the TextLabel when assigning a Dashboard and will be unique for that Dashboard. The fifth argument is the value to be displayed on the TextLabel. It can be of type **`INTEGER`**, **`REAL`**, **`STRING`** or **`BOOLEAN`**.

For example, the `Call Center` model has assigned the `Call Status.spd` Dashboard file using the name `Call Status`. The assigned Dashboard designated a Server Address of `localhost` and port `5555`. This Dashboard contains a TextLabel by the name of `TextLabel4`. During simulation, you want to display the number of Entities generated at a Generate Activity. In the Release Entity expression of the selected Generate Activity add the following line:

```
UpdateDashboardLabel("Call Status", "localhost", 5555,
   "TextLabel4", NumberGenerated);
```

While this statement may be used with any TextLabel on any assigned Dashboard, it is best used with those that have no Plot Values assigned to it. In that way, you may be certain that the value you place on the TextLabel via this statement will remain unchanged until a subsequent statement updates it.

Method UpdateDynamicLabel:

To use this method, you need to define a dynamic label in the work area first. To define a dynamic label, refer to "Dynamic Labels," beginning on page 294.

Five arguments are required for this method. The first one is **`MasterEditor`**. This is the key word that must be there and input as shown. The next two arguments are the **`Name`** and **`ID`** of the dynamic label defined in the **Background Text Properties** dialog. The fourth argument is the color to be used in displaying this label. The last argument is the value to be displayed. It can be a constant or an attribute, but the data type must match the **Mode** defined in **Background Text Properties**.

For example, you want to display the number of Entities generated at a Generate Activity. Assume you have already defined a dynamic label with the name "total," ID of 0, and data type of INTEGER. In the Release Entity event of the Generate Activity add the following line:

```
UpdateDynamicLabel(MasterEditor, "total", 0, "DarkBlue", Num-
   berGenerated);
```

The first parameter of this method must be **`MasterEditor`** and input as shown.

Methods OpenFile, CloseFile, ReadFromFile, and WriteToFile:

`OpenFile` opens the file specified in the **Filename** field for either input or output. The mode must be either "input" or "output" (not case-sensitive). "Input" opens a file to read, while "output" opens a file to write. Any other specifications will lead to an error message. Both arguments are STRING type, i.e., they must be surrounded by quotation marks. **`OpenFile`** returns an Object type value which is required in **`CloseFile, ReadFromFile`**, and **`WriteToFile`** methods.

```
OpenFile(Mode, Filename) : OBJECT;
```

By default, SIMPROCESS will look for either input or output files in the directory of the active model. Either file can be placed elsewhere as long as the path is specified in the **`OpenFile`** statement. Note that double backslashes (\\) must be used instead of single backslashes (\) in Windows file paths.

The following example opens a file (`myoutput.dat`) for output. First, define a Model Attribute **`MyOutStream`** that is type Object. If the file is to be opened in the **`Start Run`** Expression, make sure that **Do Not Reset Before Each Replication** is selected on the attribute properties dialog. If the file is opened in the Start Simulation or Start Trial expression, the file will be opened each replication. Type the following statement in one of the expressions.

```
Model.MyOutStream := OpenFile("Output", "myoutput.dat");
```

The next example opens a file (`myinput.dat`) for input and keeps the return value in the model attribute **`MyInStream`**.

```
Model.MyInStream := OpenFile("input", "myinput.dat");
```

`ReadFromFile` reads the specified numbers of values from a file that is open for input. The first argument is the input stream, from a previous **`OpenFile`** call (the file must be open for input). From the previous example, the model attribute, **`Model.MyInStream`** would be the input stream. Following the stream argument is a list of variables whose values are going to be read in from the file.

```
ReadFromFile(Input Stream, List of
   variables);
```

In the input file, values should be separated by one or more white spaces (i.e., space, tab, or new line characters). There is also a pre-defined special delimiter "|" in SIMPROCESS. You can use "|" to separate values. This delimiter is very useful to separate values (strings) that contain any white space. You can surround the whole string with a pair of "|"s, and **`ReadFromFile`** will read in whatever is in between as one value.

The input file can contain comments. Any characters that follow double forward slashes (**`//`**) will be ignored.

The type of value to be read in is dependent on the specified variable type. A mismatch will cause an error. The following table shows the valid types for different value types. Integer and real are any valid numerical values. **`ReadFromFile`** will either truncate a real value to integer for an Integer type variable, or float an integer value to real for a Real type variable. String is a sequence of characters. If spaces are included, surround the whole string with "|". Boolean can only be either TRUE or FALSE. Any other value will cause an error. Boolean values are not case sensitive.

	Value Types in File			
Variable Types	Integer	Real	String	Boolean
Integer	OK	Truncated	Error	Error
Real	FLOATed	OK	Error	Error
String	OK	OK	OK	OK
Boolean	Error	Error	Error	OK
Object	Error	Error	Error	Error

Example:

The input file contains:

```
|This is a test for ReadFromFile.|

123      67.89    TRUE
```

The expression reads as:

```
StrVal    : STRING;
IntVal    : INTEGER;
RealVal   : REAL;
BoolVal : BOOLEAN;
ReadFromFile(Model.MyInStream, StrVal, IntVal);
ReadFromFile(Model.MyInStream, RealVal, BoolVal);
```

The expression will read in the following:

```
StrVal has the value "This is a test for ReadFromFile.".
```

IntVal has the value **123**.

RealVal has the value **67.89**.

BoolVal has the value **TRUE**.

WriteToFile writes the values of the specified variables to a file that is open for output. The first argument is the output stream, that is the returned value from a previously **OpenFile** call (must be open for output). Following the stream argument is a list of variables whose values are going to be written to a file.

```
WriteToFile(Output Stream, List of variables);
```

The output values will be written to the file consecutively. Any kind of format or spacing has to be output explicitly by the user. There are two special characters that can be used in formatting outputs: "^" will write a tab to the file, while "/" will advance to a new line. For these to work correctly, they must be written individually and be surrounded by "".

For example:

Following the prior example of **ReadFromFile**, an expression has:

```
WriteToFile(Model.MyOutStream, StrVal, "/", IntVal, "^");
WriteToFile(Model.MyOutStream, RealVal, "^", BoolVal);
```

Write to the file as:

```
This is a test for ReadFromFile.

123      67.89    TRUE
```

CloseFile closes the file the IOStream pointed to.

CloseFile(IOStream);

For example:

```
CloseFile(Model.MyOutStream);
```

CloseFile(Model.MyInStream);

Close the files `myoutput.dat` and `myinput.dat,` respectively.

Typically, you will place **CloseFile** in the End Trial Expression, especially if you put **OpenFile** in the Start Trial Expression.

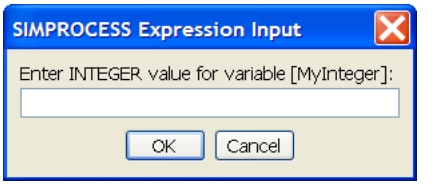
Method READ:

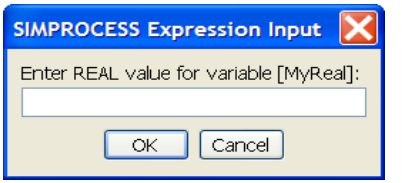
READ prompts the user for a single variable input. The variable must be a locally-defined variable (i.e., a system attribute or a user-defined attribute such as a Model, Activity, Resource, or Entity attribute cannot be referenced directly). Example:

```
MyInteger : INTEGER;
MyREAL : REAL;
READ MyInteger;
READ MyREAL;
```

The above example will provide an input prompt requesting the user to input an integer value for **MyInteger**, and the next read statement will prompt the user to input a REAL value for **MyREAL**. Type checking is done on the values entered so the user should make sure the values are compatible (i.e., don't enter “hello dolly” when prompted to enter an integer). If the value is not compatible, an error exception is thrown and the simulation stops.

The prompts for the above example would look as follows:





Method HALT:

HALT terminates the current replication or simulation. When used with no parameters, the current replication is ended and the next replication begins. This is similar to using the **Maximum Entity Count** on the Dispose Activity. **HALT** with parameters terminates the simulation in an error condition. The value of the parameters are displayed in an error dialog.

This statement is useful for debugging and stopping simulations at certain conditions in the model when developing a complex model. You may prefer the use of **OUTPUT** and **ALERT** statements to notify you of happenings in the model, but the **HALT** is there if you need it. Example:

HALT; (ends current replication)

HALT("Encountered error in Delay5"); (terminates simulation)

Method RemoteCall:

RemoteCall is a plug-in capability that can be licensed separately from CACI to allow users to make calls to external applications from within the expression scripts of a SIMPROCESS model. This feature is a powerful way to make calls to user applications (either custom developed or commercial products) based on how the business process model and workflow is planned. An example of this might be a model that represents a "To Be" business process flow for Human Resources where you intend to use a commercially available human Resources product such as Peoplesoft, Lawson, or Oracle. Based on

specific Activities in the model execution, you could make expression script calls to a user-written server that would "feed" the commercial application as a prototype to see if the product will align with the desired business process needs. The server program could "feed" the application either from native calls to the product or via other interface technologies such as XML. This capability will support analysis using models between the business functions and the system transactions that are required to support them.

The **RemoteCall** provides the mechanisms to make calls to a Java RMI server that has been registered using the Java RMI Registry. It is the responsibility of the user to develop the RMI server program and start the application. The expression script method simply has to have the name of the server computer (could be the same computer that the model is running on or could be a separate server over the network), the server object to be called, the remote method to call, and the parameter list that matches the remote procedure in the user-written server.

Example:

```
mybool : BOOLEAN;
mybool:=RemoteCall("rmi://localhost/", "server-demo", "putPlot-
 Data", SimTime, Self.NumberAccepted);
```

In the example above, a remote server application (this one happens to be running on the same computer as the model, hence the localhost URL address) called server-demo is looked up using the Java RMI registry, and the putPlotData method is called with two parameters - SimTime and NumberAccepted, where NumberAccepted is the number of Entities accepted in the Activity. (See "System Attributes" on page 512.)

The following is a description of the server application showing the actual Java code needed to implement this example. This text is not a complete reference to RMI programming, and we recommend you reference any of the many Java-published materials on RMI (java.sun.com is a good place to start).

The following is a list of the source Java programs that demonstrate the RemoteCall interface. The files are located in the **SPUser/SampleFiles** directory.

SPServerDemo.java - defines the server class and the methods that will be called from the expression script. The Java code is as follows

```
package com.caci.demo;

import java.rmi.*;

import java.util.*;

import ptolemy.plot.*;

import ptolemy.plot.plotml.*;
```

```
public interface SPServerDemo extends Remote
{  boolean putPlotData(double simtime, int totalEntities )
       throws RemoteException;
   boolean clearData()
       throws RemoteException;
}
```

SPServerDemoImpl.java - defines the implementation code for the server class and methods. This example instantiates a user-defined class that uses the Ptolemy plotting classes. This plot is being presented on the screen to the user by the server program separate from the SIMPROCESS simulation. The data being fed to the plot is coming from the simulation and the RemoteCall parameters shown above. The Java code is as follows:

```
package com.caci.demo;
import java.rmi.*;
import java.rmi.server.*;
import java.util.*;
import ptolemy.plot.*;
import ptolemy.plot.plotml.*;

public class SPServerDemoImpl
   extends UnicastRemoteObject
   implements SPServerDemo
{
public SPServerDemoImpl()
       throws RemoteException
```

```
    {
    myplot = new SPPlotDemo("Number Entities", "Simulation Time
in Hours");
    }
  public boolean putPlotData(double simtime, int totalEntities )
        throws RemoteException
    {
        myplot.putTicks(simtime, totalEntities);
        return true;
    }
    public boolean clearData()
        throws RemoteException
    {
        myplot.clearData();
        return true;
    }
    private String name;
    SPPlotDemo myplot;
}
```

SPServerDemoServer.java - defines the server binding to the RMI registry. This is necessary for Java client code (such as the RemoteCall in SIMPROCESS) to do a lookup and find the server by a name that was "binded" to the actual server class that is running on the remote server. The Java code is as follows:

```
package com.caci.demo;
import java.rmi.*;
```

```
import java.rmi.server.*;
import ptolemy.plot.*;
import ptolemy.plot.plotml.*;

public class SPServerDemoServer
{  public static void main(String args[])
   {  try
      {  System.out.println
            ("Constructing Server implementations...");
         SPServerDemoImpl d1
            = new SPServerDemoImpl();
         System.out.println
           ("Binding server implementations to registry...");
         Naming.rebind("serverdemo", d1);
         System.out.println
            ("Waiting for invocations from clients...");
      }
      catch(Exception e)
      {  System.out.println("Error: " + e);
      }
   }
}
```

SPPlotDemo.java - defines the plotting class that is instantiated in the **SPServerDemoImpl.java** class. The Java code is as follows:

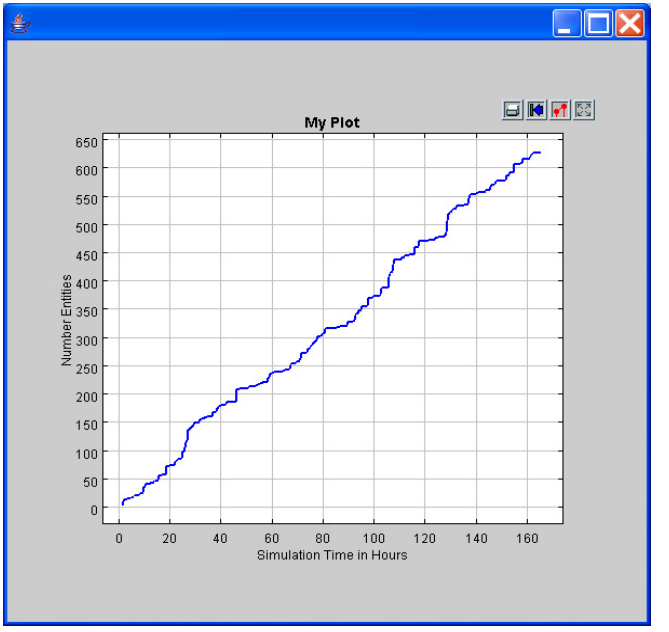
```
package com.caci.demo;
import ptolemy.plot.*;
import java.awt.GridBagLayout;
import java.awt.GridBagConstraints;
import javax.swing.JFrame;

public class SPPlotDemo extends JFrame {
Plot myPlot = null;
boolean first = true;

SPPlotDemo(String yLabel, String xLabel) {
        // Instantiate the plot.
        myPlot = new Plot();
        // Set the size of the toplevel window.
        this.setSize(600, 600);
         myPlot.setSize(550, 550);
        myPlot.setButtons(true);
        myPlot.setTitle("My Plot");
        myPlot.setXLabel(xLabel);
        myPlot.setYLabel(yLabel);
        myPlot.setYRange(0.0, 1.0);
        myPlot.setXRange(0.0, 20.0);
        myPlot.setMarksStyle("none");
        myPlot.setImpulses(false,1);
  myPlot.setConnected(true,1);
  myPlot.setBars(false);
```

```
  myPlot.setSize(350,300);
        GridBagLayout gridbag = new GridBagLayout();
        GridBagConstraints c = new GridBagConstraints();
        getContentPane().setLayout(gridbag);
        c.gridx = 0;
        c.gridy = 0;
        c.gridwidth = 1;
        gridbag.setConstraints(myPlot, c);
        getContentPane().add(myPlot);
        show();
    }
public void putTicks(double time, int num)
{
      myPlot.addPoint(1, time, num, !first);
      first = false;
      myPlot.fillPlot();
        }
public void clearData()
{
      myPlot.clear(true);
      myPlot.fillPlot();
        }
}
```

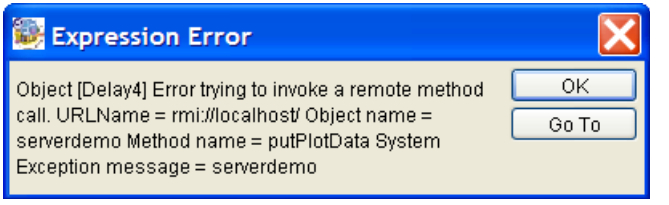
You should reference your RMI programming documentation for details on how to compile and start the server code as well as the RMI registry on a server computer. “Displaying Plots Remotely” on

page 204 has examples on starting the RMI registry.

Once you have started the RMI registry and the SPServerDemoServer program, you can run the demonstration model RemoteCall.spm to demonstrate this capability. (Chapter 5 of the *SIMPROCESS Getting Started Manual* has instructions on running this example.) When you start the simulation, the server program will put up a plot window and plot the values (SimTime and Number Accepted in this example) on the plot window. The window will appear as follows on the server:



If the server is not running, your simulation will be stopped and you will receive a message dialog stating that the server connection could not be made - similar to the following:



If your parameters don't match in number and type, RMI Exceptions will occur and a message dialog will be presented with the error. You will notice in this example that the putPlotData method expects a Java double parameter and an int parameter. The following is a mapping of the SIMPROCESS data

types that are allowed on the RemoteCall parameters and how they map to Java data types:

SIMPROCESS	Java
REAL	double
STRING	String
INTEGER	int
BOOLEAN	boolean

Method ExternalCall:

`ExternalCall` is a plug-in capability that can be licensed separately from CACI to allow users to make calls to external Java classes from within the expression scripts of a SIMPROCESS model. When calling an external Java class from an Expression using this statement, it may be necessary to add compiled Java class files to the classpath used by SIMPROCESS. See "SIMPROCESS and External Java Classes," beginning on page 602 for information on how to add external Java classes to the SIMPROCESS classpath.

Since **`ExternalCall`** is a function, a value will be returned. If the method called in the external class does not return a value (return type is void), SIMPROCESS will return the value TRUE; thus, the method should be assigned to a BOOLEAN local variable or attribute. Only valid SIMPROCESS data types can be returned (STRING, BOOLEAN, INTEGER, REAL, ANYOBJ). (For types other than ANYOBJ, see previous table in RemoteCall section for comparable Java data types. ANYOBJ can be any valid Java class.)

Method names should be unique. That is, SIMPROCESS looks for the appropriate method by name only. The number of parameters is not considered. Also, when getting a reference to the requested class, SIMPROCESS will only use constructors with no parameters.

The ExternalCall function requires two parameters: class name and method name. Other parameters after the first two are considered to be parameters for the method being called. SIMPROCESS instantiates the class once per instance of ExternalCall in a model. The instantiated class persists throughout the simulation. Thus, if the same instance of the class is needed for each invocation of ExternalCall, an instance of the class must be instantiated and returned to an Attribute of type Object. This Attribute can then be used as a parameter to static methods of the class. (See **`ExternalCall.spm`** in the **`ExpressionDemos`** directory.)

Some examples:

```
STRING : MyString;

MyString := ExternalCall("com.acme.stuff.MyClass", "getString");
```

This example returns a string value. The "getString" method has no parameters.

```
REAL : number;

number := ExternalCall("com.acme.stuff.MyClass", "getSquare",
   100.0);
```

This example returns a REAL (double) value. The "getSquareRoot" method has one parameter (double).

```
BOOLEAN : boolval;

boolval := ExternalCall("com.acme.stuff.MyClass",
   "returnNothing");
```

Note that the class name must include the package. Also, the method does not return a value (return type is void), so the function must be assigned to a BOOLEAN variable. If multiple expressions have ExternalCall methods that reference the same class, each expression will create its own instance of the class. However, if the class is static, all expressions will share the same instance.

Method ActivateGenerate:

ActivateGenerate starts the generation of Entities by a Generate Activity. For this method to work correctly, the Generate Activity must not be active. This is accomplished by setting the start date (**Start/End** tab) to a date that is past the end date of the simulation. For instance, if the simulation is scheduled to end on 1/1/2005, then the start date of the Generate Activity must be 1/1/2005 or later. Note that this is the start date of the Generate Activity, not the start date of a particular schedule within the Generate Activity. When the appropriate conditions are met in the simulation for the Generate Activity to start, issue the command along with the name of the Generate Activity. It is important that the name of the Generate Activity be unique.

```
ActivateGenerate("Generate2");
```

The **ExpressionDemos** directory has a sample model named **ActivateGenerate.spm**. If this directory is not part of the **SIMPROCESS/models** directory, it can be downloaded at www.simprocess.com.

Methods ReleaseEntity, Gate, GetEntity, EntityExists:

These methods are used in conjunction with Gate Activities. **ReleaseEntity** is used to release a specific Entity that is being held at a Gate Activity. **Gate** returns a reference to a Gate Activity. **GetEntity** returns a reference to an Entity being held in a Gate Activity. (**GetEntity** can also be used to return a reference to an Entity waiting for a Resource or return a reference to an Entity held in another Entity's batch.) **EntityExists** checks for the presence of a specific Entity at a Gate

Activity. For example:

```
gate : ANYOBJ;
entity : ANYOBJ;
i : INTEGER;
goodRelease : BOOLEAN;
gate := Gate("Gate12"); {get reference to Gate activity}
FOR i := 1 TO gate.NumberOnHold
  entity := GetEntity(gate, i); {get the entity at position i}
  IF entity.Attribute2 > 100.0
    {release the entities that match the condition}
    goodRelease := ReleaseEntity(gate, entity.SequenceNum);
    IF NOT goodRelease
      {notify of entity not released}
      OUTPUT("Entity ", entity.SequenceNum, "not released from Gate
      ", gate.Name);
    END IF;
  END IF;
END FOR;
```

EntityExists can be used to find the index position of a specific entity. For example (using the same Gate reference as the above example).

```
position : INTEGER;
{42 is the SequenceNum of the Entity desired}
position := EntityExists(gate, 42);
IF position > 0
  entity := GetEntity(gate, position);
  goodRelease := ReleaseEntity(gate, 42);
END IF;
```

The **ExpressionDemos** directory has a sample model named **ReleaseEntity.spm**. If this directory is not part of the **SIMPROCESS/models** directory, it can be downloaded at www.simprocess.com.

Methods CreateArray, GetArrayValue, SetArrayValue:

These methods are used to create and manipulate multi-dimensional arrays. **CreateArray** creates a REAL, INTEGER, BOOLEAN, STRING, or ANYOBJ array. Arrays of type REAL and INTEGER are initialized to zero. BOOLEAN arrays are initialized to FALSE. Arrays of type STRING and

ANYOBJ are not initialized with any values. **GetArrayValue** retrieves a value from an array, and **SetArrayValue** places a value in an array. (Note that if **GetArrayValue** is used with a STRING or ANYOBJ array in which the requested element has not had a value assigned by **SetArrayValue**, an error will occur.) An Attribute with a **Mode** of Object must be defined to create an array. For example, assume there is a Model Attribute named TimeArray with **Mode** Object.

```
Model.TimeArray := CreateArray("REAL", 3, 2);
```

This creates a two dimensional array for REAL numbers. The first dimension has a length of 3, and the second dimension has a length of 2. The type of array (REAL, INTEGER, etc.) must be entered as a STRING. This array can contain the delay times for 6 routes (3 origin locations and 2 destination locations). Use **SetArrayValue** to populate the array. Note that array indices are zero based. Also, the type of the value passed to the array must match the type of the array.

```
i : INTEGER;
j : INTEGER;
value : REAL;
FOR i := 0 TO 2
  FOR j := 0 TO 1
    value := DrawRealSample("Log(10, 1, 10)");
    SetArrayValue(Model.TimeArray, i, j, value);
  END FOR;
END FOR;
```

Values are retrieved from an array using **GetArrayValue**. Assume the three origin locations are represented by 0, 1, and 2, and the two destination locations are represented by 0 and 1. These are assigned to the Entity Attributes **Origin** and **Destination** (local variables would also work).

```
Entity.Origin := DrawIntegerSample("Int(0, 2, 11)");
Entity.Destination := DrawIntegerSample("Int(0, 1, 12)");
Entity.DelayTime := GetArrayValue(Model.TimeArray, Entity.Origin,
Entity.Destination);
```

Since arrays can also be of type ANYOBJ, SIMPROCESS object references (such as Activities, Entities, and Resources) can be stored in an array. For instance, a particular Activity stored in an array could be referenced in any Expression since a Model Attribute can be used in any Expression. Assume a **CreateArray** statement created a one dimensional ANYOBJ array assigned to the Model Attribute **ActivityArray**.

```
myActivity : ANYOBJ;
myActivity := Sibling("Delay12");
SetArrayValue(Model.ActivityArray, 0, myActivity);
```

The **ExpressionDemos** directory has a sample model named **CreateArray.spm**. This directory

can be downloaded at www.simprocess.com.

Method SOAPCall

The SOAPCall statement provides SIMPROCESS models with the ability to invoke methods (or operations) on Web services. It supports Web services of the "RPC" style (see note 2 below) that use the default SOAP encoding (see note 3) which is defined at http://schemas.xmlsoap.org/soap/encoding. The only methods that can be invoked are those which return data of the type typically called "xsd:string", or a fully compatible type. For more on the primitive data types, see the W3C Recommendation at http://www.w3.org/TR/xmlschema-2/.

The SOAPCall statement requires a minimum of 8 parameters. In addition, if the method (or operation) being invoked requires parameters, the SOAPCall statement will need to be given names and values for each. The following is a list of the SOAPCall parameters and a description of each, including where to find them in a typical Web Services Description Language (WSDL) file.

- ContinueOnError: A Boolean value indicating whether the simulation should continue processing if an error occurs. If false, an error terminates the simulation; if true, an error will be ignored. It's generally wise to use a false value at least until debugging has been completed. The parameter used can be a BOOLEAN or a STRING, as defined in the SIMPROCESS User's Manual. When a string is passed, any value (when converted to lowercase letters) other than "true" will be considered false.
- Endpoint URL: A string containing the URL of the endpoint for the Web service to be invoked.
- Service Name: A string containing the Service Name to be invoked, as given in the WSDL file. In a typical WSDL file, there will be a <service> element (it may optionally be namespace qualified; see note 1) near the end of the WSDL file with a "name" attribute that will provide the value to use here.
- Service Port Type Name: A string containing the name of the service's port type. This will appear in a <port> element that is a child of the <service> element above, and the "name" attribute there will provide the service port name.
- Body namespace URI: A string containing the URI used for the body namespace. Note that this is a URI, not a URL. A URI can be a URL, or it can be an identifier of another sort. It could be a string such as "urn:foo", or perhaps "dispatcher:wsdl" (as is the case in our DispatcherService WSDL file). In a typical WSDL file it can be found on the root element's "targetNamespace" attribute, or the "xmlns:tns" attribute, often in both. Though every WSDL will likely provide a value, it will not always be critical to successfully invoking the service method, however. It's best to provide it just to be certain.
- Method namespace URI: A string containing the namespace URI of the method (operation) to be invoked. The <port> element mentioned above (see the Service Port Type Name parameter) will include a "binding" attribute providing a namespace qualified name for a

binding (though most WSDL files will only have a single binding, service and port). The namespace may or may not be relevant, but the binding name found there will appear in the "name" attribute of a <binding> element (see notes 1 and 2). The child elements of the <binding> element will be <operation> elements whose "name" attribute values correspond to the available methods. Each <operation> element will have as children a <soap:operation> element (see the next parameter) as well as a pair of <input> and <output> elements. The <input> and <output> elements (the information on both should be identical, so choose one) each contain a <soap:body> child element. (See notes 3 and 4 for other important information about the <soap:body> element.) This will contain a "namespace" attribute whose value will be the method namespace URI to be used for this parameter to SOAPCall.

- SOAP Action URI: A string containing the SOAP Action URI. The <soap:operation> element described above contains a single attribute named "soapAction". Its value will very often be an empty string, though not always (see note 5). Whatever value is found in that attribute should be provided for this parameter.
- Method (operation) to invoke: A string containing the name of the method (operation) to invoke.
- Additional parameters (optional): If the method to be invoked requires passing parameters (as most do), the remaining parameters provided to the SOAPCall statement must be in matched pairs. Each pair must include a string containing the name of the parameter, and a value to be passed for the named parameter at invocation.

    a. Parameter name: Refer to the <binding> element mentioned above. It will contain a "type" attribute providing the namespace qualified name for a "port type". This will refer to a <portType> element with a "name" attribute whose value is the same. The child elements of <portType> will be <operation> elements (one for each available operation) containing two key pieces of information:

        i. The value of the "name" attribute corresponds to the name of the method (operation) to be invoked.

        ii. The value of the "parameterOrder" attribute will list the names of all parameters that must be passed (the values to be included here in the SOAPCall statement), and the order in which they must appear.

    b. Parameter types: Although SOAPCall can only invoke operations returning the "xsd:string" (or fully equivalent) type as stated above, it can invoke operations whose parameters are functionally compatible with the SIMPROCESS types INTEGER (xsd:int), REAL (xsd:double), STRING (xsd:string) or BOOLEAN (xsd:boolean) as defined in the SIMPROCESS User's Manual. Internally, SOAPCall checks the parameters passed to ensure that they are of the allowable SIMPROCESS types. It then assumes that the operation's named parameter is of the corresponding SOAP type. Only testing the SOAPCall statement with a specific operation will determine whether it can be used. (See note 6 for more information.)

Notes:

1. Depending on the developer of a Web service and the toolset(s) used, the element names appearing in a WSDL file may be qualified with a namespace. For instance, the structure of a WSDL file is mandated by standard which is sometimes referred to via namespace, so that all the elements in a WSDL file may be qualified, like <wsdl:definitions> or <wsdl:operation>. When this approach is used, there will be a namespace reference in an attribute on the root element of the WSDL file, such as xmlns:wsdl="http://schemas.xmlsoap.org/wsdl", indicating the namespace prefix (e.g., “wsdl”) and the URI of the namespace. Much of the above information is based on the assumption that WSDL file elements are not namespace qualified, as is true of SIMPROCESS' DispatcherService.

2. A typical <binding> element (optionally namespace qualified; see note 1) will be immediately followed by a <soap:binding> element with a “style” attribute. SOAPCall only works with those having a value of “rpc” here; if the style is “document” the SOAPCall statement cannot be used with this service.

3. The <soap:body> element within each <operation> element (optionally namespace qualified, as per note 1) should contain an attribute named "use". This attribute should have a value of “encoded”; if its value is “literal”, the SOAPCall statement cannot be used with this service.

4. The <soap:body> element within each <operation> element (optionally namespace qualified; see note 1) should contain an attribute named “encodingStyle”. Its value should be http://schemas.xmlsoap.org/soap/encoding/ which defines the standard encoding for SOAP 1.1. If any other URL is used, it may not be possible to use SOAPCall with this service.

5. Many services will indicate that the SOAP Action URI is only meaningful if the transport is HTTP. Because SIMPROCESS is a Java application, it uses HTTP transport automatically in most environments, so this value should always match that found in the WSDL file. If it isn't needed, the environment will transparently discard it.

6. There is no limit to the type of information that can be exchanged between client applications and Web services using SOAP. There is, however, a practical limitation to how the SOAPCall statement can be prepared in advance to interact with Web services chosen by SIMPROCESS users. Internally, SIMPROCESS uses what is known as the Dynamic Invocation Interface to build and invoke the call to a Web service operation. Other available approaches require prior knowledge of the WSDL file and require generation and compilation of Java code to call it. This simply isn't possible in a runtime environment. As a result, we've had to select the best all around means of offering access to Web services via SOAP. In the future, as available tools for runtime examination of WSDL files improve, perhaps SIMPROCESS will be able to improve the SOAPCall statement to provide still greater capabilities.

Methods CreateMap, PutInMap, GetFromMap, RemoveFromMap, ClearMap, GetMapKey, GetMapSize:

These methods are used to create and manipulate hashmaps. **CreateMap** creates a hashmap that stores REAL, INTEGER, BOOLEAN, STRING, or ANYOBJ values. **PutInMap** places a keyed value into a hashmap. The key can be of type REAL, INTEGER, BOOLEAN, STRING, or ANYOBJ. The value must match the type used in **CreateMap**. **GetFromMap** retrieves a value from a hashmap without removing the value from the hashmap. **RemoveFromMap** retrieves a value from a hashmap and removes the value and its key from the hashmap. **ClearMap** removes all values from the hashmap along with their associated keys. **GetMapSize** and **GetMapKey** are usually used when iterating through a map. An Attribute with a **Mode** of Object must be defined to create a hashmap. For example, assume there is a Model Attribute named Map with **Mode** Object (with **Do Not Reset Before Each Replication** selected). The following statement should go in the **Start Run** Expression of the **Model Expressions**.

```
Model.Map := CreateMap("ANYOBJ");
```

This creates a hashmap that will store any type of object. Use **PutInMap** to place values in the hashmap. For instance assume that there are several activities that will need to be referenced throughout the model. Certain decision points will required knowledge of how many entities are currently in these activities. The following could go into the **Start Simulation** expression of each activity.

```
PutInMap(Model.Map, Name, Self);
```

This places each activity into the hashmap with the name of the activity as the key to the value (the activity itself). Note that the keys must be unique. Thus, if two activities being placed into the hashmap have identical names, only the last one placed in the hashmap will be there. The last one put in the map will replace the previous entry.

Assume in the **Accept Entity** expression of a Branch Activity we need to determine the appropriate path for the incoming Entity based on information from the Activities in the hashmap. In this example there are two Activities in the hashmap: **Call Wait Queue** and **Calls In Service**. GetFromMap can be used to retrieve each Activity and check each Activity's status.

```
callWait : ANYOBJ;
callService : ANYOBJ;
callWait := GetFromMap("Call Wait Queue");
callService := GetFromMap("Calls In Service");
IF callWait.NumberIn > 100 AND callService.NumberIn > 25
   Entity.Reject := TRUE;
END IF;
```

RemoveFromMap also returns the value stored in the hashmap, but it also removes the value from the map. Thus if the statements below were used, the next entity entering the Branch Activity would get an error since the Activities no longer exist in the hashmap.

```
callWait := RemoveFromMap("Call Wait Queue");
```

```
callService := RemoveFromMap("Calls In Service");
```

RemoveFromMap should be used when the values in the hashmap are temporary in nature, such as Entities. If temporary objects are placed into a hashmap, it is important that they be removed before being disposed. If not, memory used by the temporary object will not be freed.

ClearMap should normally be used in the End Run expression. It ensures that unneeded memory is freed at the end of the simulation.

```
ClearMap(Model.Map);
```

GetMapSize returns the number of objects in a hashmap. This number can be used to iterate through the hashmap using **GetMapKey** in a **FOR** loop. The type (INTEGER, REAL, etc.) of the variable that will contain the key returned by **GetMapKey** must match the type of the key returned. (Thus, it is recommended that all the keys be of the same type for a particular hashmap.) The example below shows iterating through a hashmap that contains Entities keyed by their **SequenceNum**. Items should not be added to or removed from a hashmap when iterating through a hashmap.

```
size : INTEGER;
count : INTEGER;
key : INTEGER;
entity : ANYOBJ;
size := GetMapSize(Model.Map);
FOR count := 1 TO size
   key := GetMapKey(Model.Map, count);
   entity := GetFromMap(Model.Map, key);

   {Alternatively, the above two lines could be replaced with
   entity := GetFromMap(Model.Map, GetMapKey(Model.Map, count));}

   IF entity.HoldTime > 200.0
      entity.Reject := TRUE;
   END IF;
END FOR;
```

SIMPROCESS Color Table

0	Black (Default)	33	SandyBrown
1	White	34	Gold
2	Red	35	Goldenrod
3	Green	36	LightGrey
4	Blue	37	MediumGoldenrod
5	Yellow	38	DarkOliveGreen
6	Cyan	39	ForestGreen
7	Magenta	40	LimeGreen
8	DarkGrey	41	MediumForestGreen
9	Grey	42	MediumSpringGreen
10	DarkRed	43	PaleGreen
11	DarkGreen	44	SeaGreen
12	DarkBlue	45	YellowGreen
13	DarkYellow	46	DarkSlateGrey
14	DarkCyan	47	DimGrey
15	DarkMagenta	48	Khaki
16	Aquamarine	49	Maroon
17	MediumAquamarine	50	Orange
18	CadetBlue	51	Orchid
19	CornflowerBlue	52	DarkOrchid
20	DarkSlateBlue	53	Pink
21	LightBlue	54	Plum
22	LightSteelBlue	55	IndianRed
23	MediumBlue	56	OrangeRed
24	MediumSlateBlue	57	VioletRed
25	MidnightBlue	58	Sienna
26	NavyBlue	59	Tan
27	SkyBlue	60	Turquoise
28	SlateBlue	61	DarkTurquoise
29	SteelBlue	62	Violet
30	Coral	63	Wheat
31	Firebrick	64	GreenYellow
32	Brown		

APPENDIX G

External Event Files

The Generate activity offers a File schedule. This appendix describes the format for the event file associated with the File schedule.

General Rules for Event Files

External event files define entity generation events. If event files are referred to in a Generate activity, SIMPROCESS reads the file at the beginning of a simulation run and schedules the generation of Entities as defined in the file.

Each record (line) in an event file must adhere to certain syntax rules, which are defined in the following section. Records must also adhere to these general rules:

- Each record in the file defines one generation event. There is no way to continue a record on the following line.
- The keywords (ENTITY, QUANTITY, etc.) followed by a colon (:) or equals sign (=) must not have any spaces between the colon or the equals sign and must not have any spaces between the colon or equals sign and the value associated with the keyword.
- The keywords and values are case sensitive.
- Records must be ordered by entity create time. SIMPROCESS will not generate entities for any event record whose entity create time is earlier than that of the previously processed event. For example, in the following sequence of creation dates:

    1. 01/02/2005
    2. 01/04/2005
    3. 09/11/2004
    4. 10/30/2004
    5. 01/12/2005

Records 1 and 2 are processed. Record 3 is bypassed, because its creation date is earlier than that of record 2. Record 4 is also bypassed, because its date is earlier than that of record 2, the last record for which entities were generated.

- Entity create time must be the first field in the event record. The remaining keyword parameters may be entered in any order.
- The entity type you specify in an event record must be defined to the model before it can be generated.

However, you can refer to a new type in the event file and select the **Selected in the list** option in the **External File Schedule** dialog. SIMPROCESS will automatically add it to the model.

- Any literal values with imbedded blanks must be enclosed in quotation marks (" ") when included in event records.
- Real numbers must include a decimal point.

- Records beginning with an asterisk (*) are considered comments and are ignored by SIMPROCESS.

Event Record Description

In the following syntax diagram:

- Items in **BOLD** face must be entered exactly as shown.
- Items in *italic* face represent variables for which you must substitute a value.
- Items enclosed in brackets ([]) are optional.

Syntax

[+]*time* [**QUANTITY:***value*] [**ENTITY:** *type*] [**ATTR:** *name*=*value*...]

Parameters

+

Indicates that the ensuing value is to be added to the time of the last event processed.

time

The time at which entities are to be created for this event record. Specify either a specific date and time or a relative value. Use the following format for a specific date and time:

mm/*dd*/*yyyy hh:mm:ss*

Where, for example, January 15, 2007, at noon is represented as:

01/15/2007 12:00:00

You can enter either real numbers or integers to indicate relative values: real numbers are assumed to refer to hours, while integers refer to days. Forty-eight hours after the start of simulation is shown as:

48.0

Which is the same as two days after the start of the simulation:

2

Forty-eight hours after the previous entity generation event:

`+48.0` **or** `+48:00` **or** `+2`

Notes on specifying event time:

- You can omit seconds when specifying the time. SIMPROCESS assumes a zero for the omitted parameter.
- Do not specify a time in *hh:mm* without a date, unless you precede it with a plus sign (+). Although SIMPROCESS will accept this value, its interpretation is unpredictable. For example, acceptable formats are:

  `48.0` 48 hours after the start of simulation

  `+48:00` 48 hours after previous generation event

- SIMPROCESS will accept a 2-digit value for the year, It assumes that values over 49 refer to years in the 20th century, and values under 50 refer to the 21st century.

QUANTITY:value

The number of entities to generate at the entity generation event. Enter a number in place of *value*.

If QUANTITY is omitted, SIMPROCESS uses the default **Quantity** value in the **Generate Activity Properties** dialog.

ENTITY: type

The type of entity to generate.

For *Type,* enter an entity type name. If the name includes blanks, enclose the entire string in quotes.

If ENTITY is not specified, SIMPROCESS uses the default Entity value in the **Generate Activity Properties** dialog.

ATTR: name=value...

Assigns values to globally defined attributes for entity instances.

You can assign values to any number of attributes in the VARS argument.

The *value* you specify must be consistent with the data type defined for the attribute.

Note that if you specify an attribute name that has not been defined in your model, you can select the **Selected in the list** option in the **External File Schedule** dialog. SIMPROCESS will add it to the model.

If a record contains any syntax error or undefined model element (without using **Selected in the list** option), the entire event record is considered invalid and is bypassed.

Examples

1. Generate `GreenDot` entities at 3 a.m. on January 1, 2005. Generate the number of entities defined in the **Generate Activity Properties** dialog.

```
01/01/2005 03:00:00 ENTITY:GreenDot
```

2. Generate six `RedDot` entities 7 hours after the simulation begins.

```
7.0 QUANTITY:6 ENTITY:RedDot
```

3. Generate four `RedDot` entities 7 hours after the previous entity generation.

```
+7:00 QUANTITY:4 ENTITY:RedDot
```

4. Generate a Truck entity at 2 a.m. on January 3, 2005. Assign a value of 50,000 to user attribute *Weight*, and the string "Yo, Heavy" to user attribute *Tag*:

```
01/03/2005 2:00 ENTITY:Truck ATTR:Weight=50000 Tag="Yo, Heavy"
```

5. Generate more Truck entities 4 hours after the previous event. Generate the number of entities defined in the `Generate Activity Properties` dialog:

```
+4.0 ENTITY:Truck
```

6. Generate two `RedDot` entities at 4 a.m. on January 3, 2005:

```
01/03/2005 04:00:00 ENTITY:RedDot QUANTITY:2
```

Notes on the Examples

If the examples are processed during a simulation which begins at midnight, January 1, 2005, the events occur at the following times:

1. January 1, 2005, 3:00 a.m.
2. January 1, 2005, 7:00 a.m.
3. January 1, 2005, 2:00 p.m. (14:00)
4. January 3, 2005, 2:00 a.m.
5. January 3, 2005, 6:00 a.m.
6. Never. The specified time is earlier than the time of the previous event, so the record is discarded.

APPENDIX H

Simulation Results File

The Simulation Results file is generated from the **File** menu. Select **File/Export/Simulation Results** to open the **Save Statistics** dialog. The Simulation Results file will, by default have a `.xpt` file extension and be saved to the current model directory. This file is tab-delimited, and can be opened using a text editor or spreadsheet.

The file will contain the complete statistical measures corresponding to the reports selected for the current model. This file give you raw statistical data that is displayed in the Standard and Custom Reports, in a standard format that can be opened by many different applications.

Format of the Simulation Results File

Each line of the exported simulation results file is a statistic recorded for objects such as Entity Types, Activities, or Resources. Each record contains the following fields or columns:

Owner Type

This is the type of the object that owns this statistic record. The four types are:

- **Entity**: representing an Entity Type
- **Activity**: representing an Activity
- **Resource**: representing a Resource
- **TimeStamp**: representing a Time Stamp
- **Attribute**: representing an Attribute

Owner Name

This is the full hierarchical name of the specific object that owns this statistic record.

Name

This is the name of the specific object that owns this statistic record.

Stat Type

This is the type of statistic displayed. Contained in the third column from the left, the Stat Type is an abbreviation for the name of the performance measure whose parameters follow to the right. See “Statistic Types,” beginning on page 586 for a complete description of the types of statistics.

Replication

This number is the replication that the statistic was collected from. Any number, 1 or greater, refers to a specific replication.

If the replication number is 0, the statistics are sum of all replications. An -1 means that this statistic is the average of all replications.

Minimum

This is the smallest value that has been recorded for this statistic.

Maximum

This is the largest value that has been recorded for this statistic.

Sum

It is the total of all observed values for the statistic (i.e. X_i), if this is observation based.

For time weighted, it is the total of each observed value multiplied by the time that this value has persisted in (i.e. $X_i * \Delta T$).

Sum of Squares

It is the summation of the square of each observed values (i.e. $\sum(X_i^2)$), if this is observation based.

For time weighted, it is the summation of the square of each observed value multiplied by the time that this value has persisted in (i.e. $\sum(X_i*\Delta T)^2$).

Count

This is the number of observations recorded when the statistic was collected.

Average

This is the average of the statistic.

Std Deviation

This is the standard deviation of the statistic.

Statistic Types

The table below gives the descriptions of the statistic types within SIMPROCESS.

Labels	Type of Statistics	Descriptions
Entities:		
tokendelay	Observation based	Total cycle time (i.e. sum of wait, hold, and process)
tokenwaitdelay	Observation based	Time waiting for available resource
tokenholddelay	Observation based	Time waiting for condition to be reached
tokenprocessdelay	Observation based	Time processing (i.e. at specified duration)
tokentraveldelay	Observation based	Time traveling across connectors.
tokenlevel	Time-weighted	Number of entities in system
tokenwaitlevel	Time-weighted	Number of entities waiting for available resource
tokenholdlevel	Time-weighted	Number of entities waiting for condition to be reached
tokentravellevel	Time-weighted	Number of entities traveling across connectors.
tokenprocesslevel	Time-weighted	Number of entities in process (i.e. at duration)

Labels	Type of Statistics	Descriptions
tokentotalborn	Only the last value is recorded	Number of entities being generated
tokentotalalive	Only the last value is recorded	Number of entities still residing in the system
tokentotalkilled	Only the last value is recorded	Number of entities destroyed
UDV.delay	Observation based	Statistic of the specified attribute
UDV.level	Time-weighted	Statistic of the specified attribute
Resources:		
resrccap	Time-weighted	Units of resources (i.e. capacity)
resrcidle	Time-weighted	Units of idle resources
resrcbusy	Time-weighted	Units of busy resources
resrcmaintenance	Time-weighted	Units of resources not available (Unplanned Downtime)
resrcdown	Time-weighted	Units of resources not available (Planned Downtime)
resrcreserved	Time-weighted	Units of reserved resources
byactivitybusy.level	Time-weighted	Units of busy resources at the specified activity
Connectors:		

Labels	Type of Statistics	Descriptions
tokentotalin	Only the last value is recorded	Number of entities entered this connector
tokentotalhere	Only the last value is recorded	Number of entities still residing in this connector
tokentotalout	Only the last value is recorded	Number of entities that have left this connector
bytokenin	Only the last value is recorded	Number of entities of the specified type that entered the connector
bytokenhere	Only the last value is recorded	Number of entities of the specified type still residing in the connector
bytokenout	Only the last value is recorded	Number of entities of the specified type that have left the connector
tokendelay	Observation based	Total cycle time at this connector
bytoken.delay	Observation based	Total cycle time for the specified entity type at this connector
tokenlevel	Time-weighted	Number of entities in this connector
bytoken.level	Time-weighted	Number of entities of the specified type in this connector
Activities:		
tokentotalin	Only the last value is recorded	Number of entities entered this activity

Labels	Type of Statistics	Descriptions
tokentotalhere	Only the last value is recorded	Number of entities still residing in this activity
tokentotalout	Only the last value is recorded	Number of entities that have left this activity
tokentotalearlyout	Only the last value is recorded	Number of entities that left the activity without processing
bytokenin	Only the last value is recorded	Number of entities of the specified type that entered the activity
bytokenhere	Only the last value is recorded	Number of entities of the specified type still residing in the activity
bytokenout	Only the last value is recorded	Number of entities of the specified type that have left the activity
bytokenoutearly	Only the last value is recorded	Number of entities of the specified type that left the activity without processing
tokendelay	Observation based	Total cycle time (i.e. sum of wait, hold, and process) at this activity
tokenwaitdelay	Observation based	Time waiting for available resource at this activity
tokenholddelay	Observation based	Time waiting for condition to be reached at this activity

Labels	Type of Statistics	Descriptions
tokenprocessdelay	Observation based	Time processing entities (i.e. in the specified durations) at this activity
bytoken.delay	Observation based	Total cycle time (i.e. sum of wait, hold, and process) for the specified entity type at this activity
bytokenwait.delay	Observation based	Time waiting for available resource for the specified entity type at this activity
bytokenhold.delay	Observation based	Time waiting for condition to be reached for the specified entity type at this activity
bytokenprocess.delay	Observation based	Time processing entities (i.e. in the specified durations) for the specified entity type at this activity
tokenlevel	Time-weighted	Number of entities at this activity
tokenwaitlevel	Time-weighted	Number of entities waiting for available resource at this activity
tokenholdlevel	Time-weighted	Number of entities waiting for condition to be reached at this activity
tokenprocesslevel	Time-weighted	Number of entities in process (i.e.at duration) at this activity
bytoken.level	Time-weighted	Number of entities of the specified type at this activity

Labels	Type of Statistics	Descriptions
`bytokenwait.level`	Time-weighted	Number of entities of the specified type waiting for available resource at this activity
`bytokenhold.level`	Time-weighted	Number of entities of specified type waiting for condition to be reached at this activity
`bytokenprocess.level`	Time-weighted	Number of entities of the specified type in process (i.e.at duration) at this activity
`UDV.delay`	Observation based	Statistic of the specified attribute
`UDV.level`	Time-weighted	Statistic of the specified attribute
Time Stamps:		
`tokendelay`	Observation based	Time elapsed between Time Stamps

APPENDIX I

UML Interfaces

SIMPROCESS and Unified Modeling Language (UML) tools complement each other by bridging the gap from business analysis to systems analysis. SIMPROCESS is used for the business process models, and UML tools are used for the systems models. These tools work together in documenting the operational architecture of a business. They communicate the content of the business requirements and the systems requirements and designs by using both notations in combination.

UML-based tools such as Rational Rose focus on Systems Modeling to help define requirements, model designs, and develop object-oriented code such as Java. Rational Rose is one of the leading tools on the market for system modeling activities in a software development life cycle, but other capable tools support the UML standard.

UML tools do not fully address the functional/business process modeling requirements. For example, Use Cases and Activity Diagrams are the only views UML has for modeling any part of the business process, but they still focus on the "system" needs in the models rather than the function or business steps. For instance, Use Cases show Actors (usually people) interacting with objects (usually realized as object oriented components such as Java classes). This helps to understand the system transactions but does not model the full breadth of the business workflow or process. Activity diagrams similarly model activity steps that can be used to model business flow diagrams but typically focus on objects and transition of states between objects based on changes to the objects in a system transaction. Activity diagrams do not provide the dimensions needed to do robust business process analysis such as dynamic modeling, entity flow simulations, resource utilization, queueing theory, and cost based business metrics.

SIMPROCESS focuses on the functional and business work flow (including manual/physical processes that have nothing to do with the system but need to be understood and modeled in order to build a system to support the business properly) and not just on the system transactions. This is made clear when looking at how activities such as delays, splits, joins, batching, unbatching, assembling, etc., are described for behavior in a SIMPROCESS model. These are representative of business activities that people do in carrying out their jobs regardless of what interaction they have with the system. In addition, SIMPROCESS looks at the resources, entities, and workflow as a complete dynamic model that allows visualization of how the business works both from manual steps and system interaction. This is important in order to match up the business transactions with the system transactions.

SIMPROCESS has a more functional and business view and focuses on activity based costing metrics, throughput, bottlenecks, timing, re-work and other business performance metrics regardless of the system that is supporting the business. This is why business and functional representatives prefer SIMPROCESS for the business modeling - it speaks their language. SIMPROCESS focuses on the business concerns and not all the system modeling notations and methods (which often confuses functional people). The dynamic modeling capabilities for business metrics are non-existent in UML modeling tools. This is appropriate since UML tools are system analysis, design, and development tools, not process and workflow modeling tools.

There is a clear gap between business analysis and systems analysis. SIMPROCESS focuses on the business analysis and UML tools focus on the systems analysis. Clearly, both are needed from business requirements to systems requirements to system design to system development. They work hand in hand and not in opposition to each other. This gap in business analysis and systems analysis is the basis for the SIMPROCESS to UML interfaces. These interfaces use the complementary strengths of both UML and SIMPROCESS to provide customers a complete toolset for business and systems modeling.

SIMPROCESS has two basic interfaces to UML. One is the ability to export a SIMPROCESS model to a UML Activity Diagram. The export to Activity Diagrams is based on the standard UML XMI specification and provides a transfer of the SIMPROCESS activities and connectors to UML activities and transitions. In addition, SIMPROCESS Entities and Resources are exported as UML Classes (with attributes included); however, the classes are not accompanied by a UML Class Diagram. The Activity Diagram includes the Diagram information for Rational Rose only. The XMI activity information can be imported into any UML tool other than Rational Rose that supports XMI by simply deleting the Diagram information at the bottom of the XMI file that is created from the export process.

The other type of interface is an active link between activity nodes on a SIMPROCESS model and Use Case Diagrams in a Rational Rose model. This interface requires a Microsoft Windows version of SIMPROCESS and a licensed copy of Rational Rose.

Each type of interface is described in more detail in the following sections.

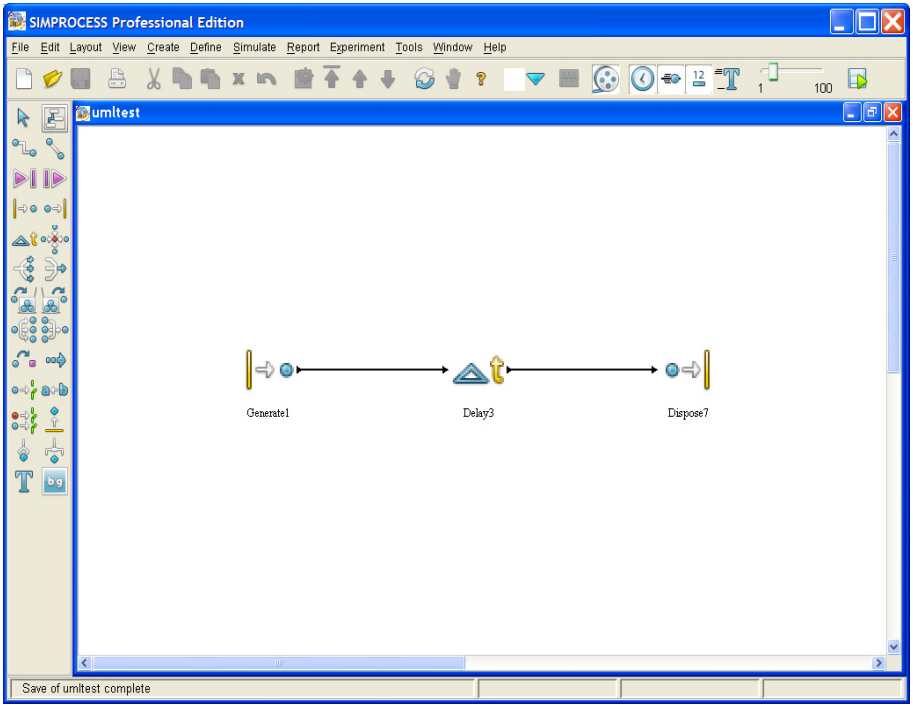
Exporting to UML

This capability can be used by selecting **File/Export/UML Activity Model** from the SIMPROCESS menus. It outputs the model to a UML compatible XML file. No dialog is displayed for this export operation. The file is created in the model's directory with a `.xml` extension and is compatible with Rational Rose, including diagram information. The XMI file may be compatible with other UML tools as well, such as the ArgoUML open source tool, but diagram information intended for Rational Rose will not be compatible with other UML tools.

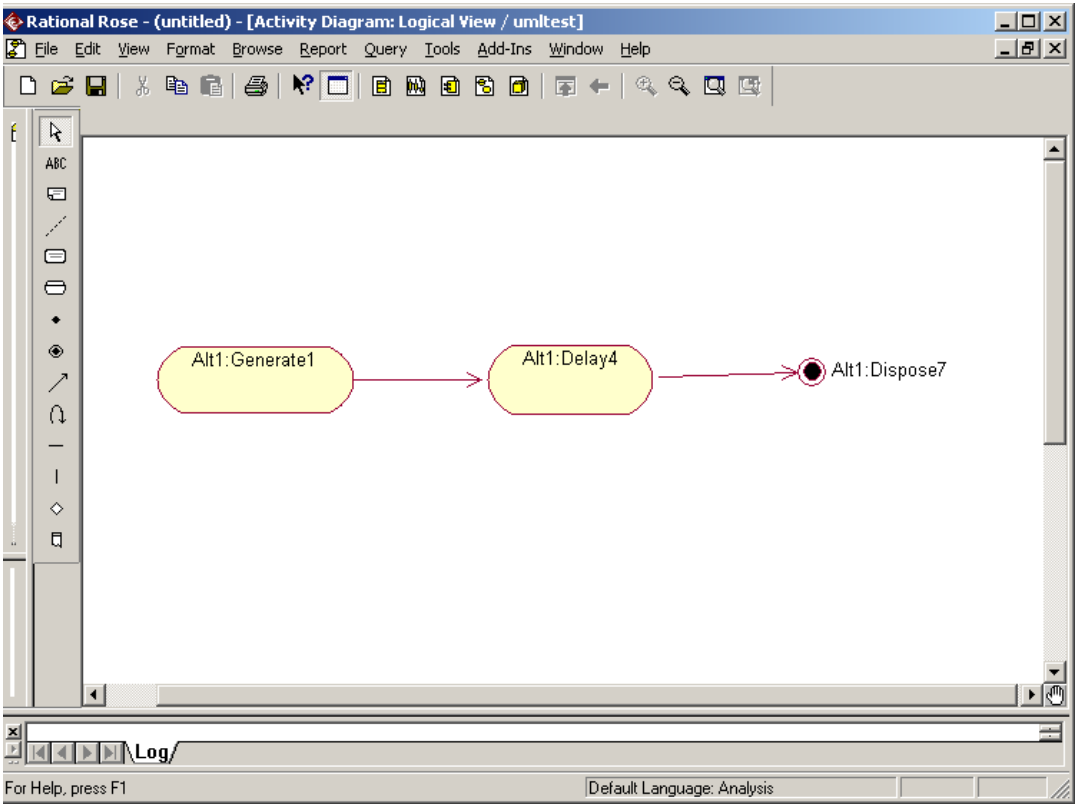
To import the model into Rational Rose, Rational Rose must have the Import/Export XMI plug-in installed. This plug-in can be obtained from the Rational Rose web site (www.rational.com). Once it is installed, simply choose the **Import UML Model** from the **Tools** menu in Rational Rose.

In some cases, due to slight differences in the aspect ratio of the graphics in SIMPROCESS and the Rational Rose tools, minor visual clean up of the imported Activity Diagram may be required.

The following is a simple SIMPROCESS model that is exported to UML:



The above SIMPROCESS model would look like the following in Rational Rose:

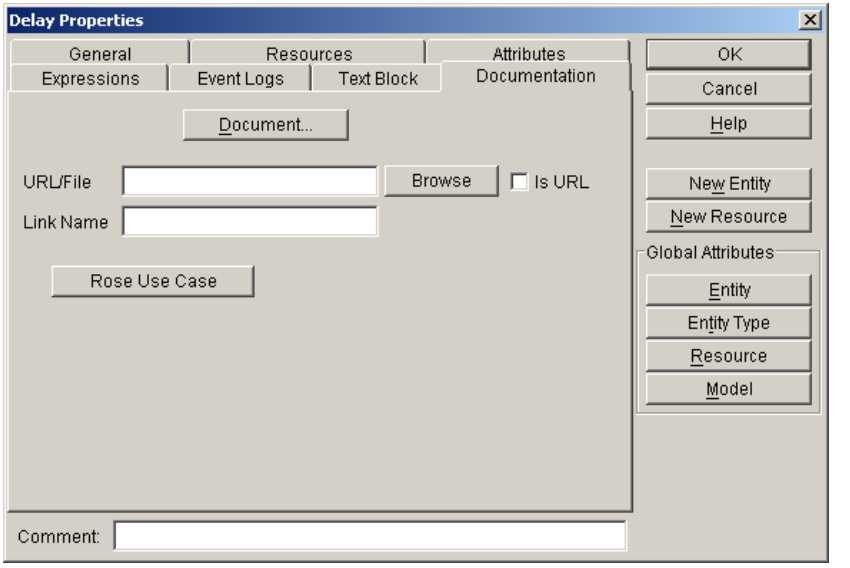

Rational Rose - (untitled) - [Activity Diagram: Logical View / umltest]
File Edit View Format Browse Report Query Tools Add-Ins Window Help
ABC
Alt1:Generate1
Alt1:Delay4
Alt1:Dispose7
Log
For Help, press F1
Default Language: Analysis

Rose Use Cases

SIMPROCESS provides the capability for the user to connect nodes (activities) on the SIMPROCESS model directly to a Rose Use Case Diagram. This allows for a seamless flow from business process modeling and simulation analysis in SIMPROCESS to systems models in Rose. Exported HTML views of the SIMPROCESS models (page 23) are directly linked to Rational Rose exported HTML models. This gives stakeholders a seamless wide area review of the business process models with Rose Use Case models. SIMPROCESS models typically include both manual process steps (activities) and steps that are automated with information technology. This capability ties the manual process steps and the automated process steps (supported by Use Case links) together so that the system requirements are in complete context with the business process.

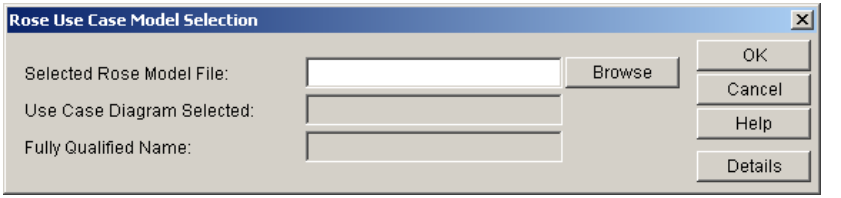
This feature is licensed by CACI separately from SIMPROCESS and is only available with the Windows version of SIMPROCESS. For this feature to be active, the additional license must be purchased, and Rational Rose must be installed.

Rose Use Case links are added by selecting the **Rose Use Case** button on the **Documentation** tab on any activity properties dialog. This button will only be enabled if the above criteria are met.



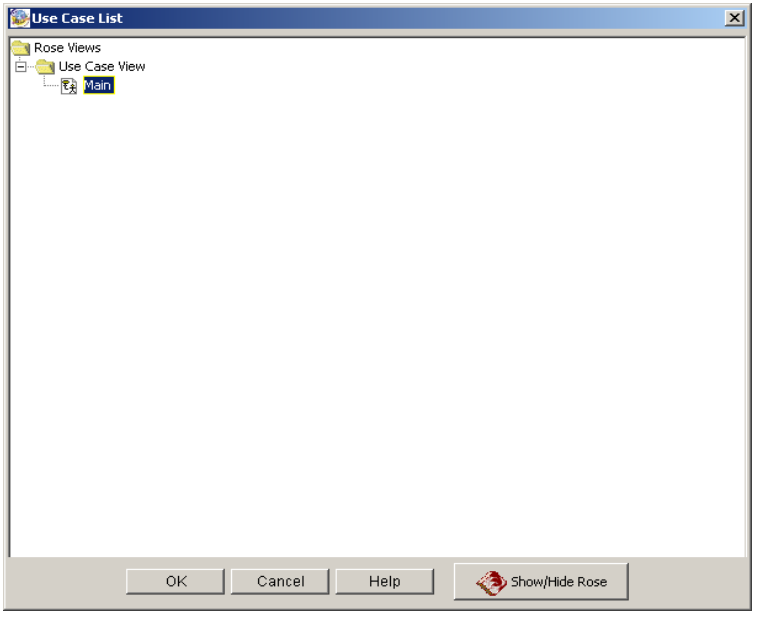
Clicking **Rose Use Case** brings up the following dialog. The path to a Rose model file can be entered or the **Browse** button can be used to select a Rose model file. Once a Rose model has been selected, a reference to it is stored in the SIMPROCESS model file for subsequent use (this reference will be invalidated if the file is later moved or renamed). The connection to a Rose model remains until the

model file name is cleared, and the **OK** button is clicked.



Once a Rose model is connected to the SIMPROCESS model, the **Details** button will connect SIMPROCESS to a licensed copy of Rational Rose using the Rational Rose Automation capability. If a successful connection and load of the Rose model is completed (this occurs in the background), a window like the one shown below is presented listing all the Rose views and subordinate packages that contain Use Case Diagrams. Note that if a package or view does not contain any Use Case Diagrams, it is not included in the window since the SIMPROCESS connection is to Use Case Diagrams only.

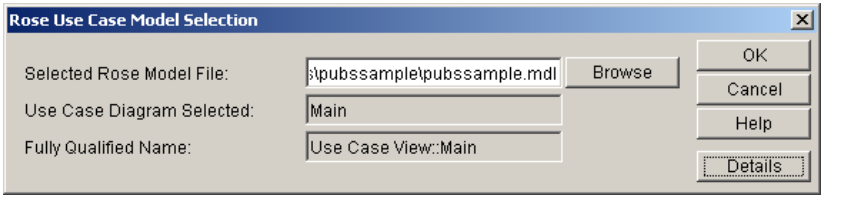
Utilizing this window, a Use Case Diagram can be navigated to and selected to associate with the SIMPROCESS activity node. Note that the structure in the dialog is a simple Tree structure that works like other graphical file directory trees.



A single Use Case Diagram can be selected by clicking on it and then clicking the **OK** button. This

action will assign that Use Case Diagram to the SIMPROCESS activity node. Optionally, the **Show/Hide Rose** button can be selected to bring the Rose tool and model up on the screen so that it is available. Once Rose is visible the Rose model can be modified as desired, and the Rose model can be saved. However, any new Use Case Diagrams added will not automatically appear in the SIMPROCESS Use Case List window until it is closed and reopened.

After a Use Case Diagram is selected and the **OK** button is clicked, the Use Case Diagram information will be added into the SIMPROCESS dialog, as shown below. The Use Case Diagram name and fully qualified name (which includes the entire package structure in Rose) are not directly editable. To clear the Use Case Diagram connection, simply select and clear the **Selected Rose Model File** field in this dialog and click **OK**. To change the **Use Case Diagram Selected** (the node to which SIMPROCESS is connected), simply click on the **Details** button and choose another Rose Use Case Diagram from the Use Case Diagram dialog as described above.



An important feature of this Use Case Diagram connection between SIMPROCESS and Rational Rose is that when the Rose model is published to HTML and the SIMPROCESS model is published to HTML, the SIMPROCESS HTML nodes will be automatically linked to the Rose Use Case Diagrams in the HTML. For this feature to work, the Rose published model must be in a directory named `rose` within the directory of the SIMPROCESS published model on the disk drive or web server. When navigating the SIMPROCESS published HTML model, moving the mouse pointer over a SIMPROCESS activity node that has been connected to a Rose Use Case Diagram as described in this section gets a Javascript popup that links directly to the Rose published HTML Use Case Diagram automatically. This capability is very useful for wide area review of business process models that have Use Case functional requirements attached to certain nodes in the SIMPROCESS model. Hence, the business process requirements and the system requirements are in context of each other using this technique.

APPENDIX J

Running Models Without GUI

SIMPROCESS models can be run without the SIMPROCESS Graphical User Interface (GUI). There are two executables in the SIMPROCESS directory: SIMPROCESS and SPRunSimulation (any extensions are platform specific). The SIMPROCESS program starts the SIMPROCESS GUI, required to build and edit models. This GUI is typically used to run models as well. However, SPRunSimulation can be used to run a SIMPROCESS model without the GUI. A valid `license.dat` file is required to run SIMPROCESS and SPRunSimulation. The same license file is used for both.

Since access to the GUI is not available, results of the run must be automatically output to the SIMPROCESS database (see page 375), user created files, or a user created database. Statistics collected during the run can be accessed using System Methods. (See "Accessing Statistics During Simulation" on page 308.) The Standard Report can be generated automatically after the run by selecting **Generate Standard Report after run** on the **Statistics Collection** dialog. (See "Generating Standard Reports From Experiments" on page 399.)

To run a model with SPRunSimulation, either execute commands from a command prompt or create a batch file or a shell script. The command must include SPRunSimulation and the complete path to the model that is to be run, as shown in this example for Windows.

```
SPRunSimulation "C:\Program
Files\SIMPROCESS\models\Demos\Purchasing.spm"
```

The above is the simplest form for running a model without the GUI. However, model parameters (see page 243) and process alternatives can be set as well as the number of replications. In addition, the simulation results can be automatically placed in the SIMPROCESS database, and the model can be

saved. These options can be set either on the command line or by using a properties file.

Available Options

The following options can be set on the command line or in a properties file. The format of the option is always the name of the option followed with no spaces by an equals sign followed with no spaces by the value.

- Any global attribute designated as a model parameter - Model.NumResource1=2
- Any process alternative - "Process name=Alternative name"
- Number of replications - Replications=5
- Design for committing the results to the SIMPROCESS database - "Design=My Design"
- Scenario for committing the results to the SIMPROCESS database (must be used if Design is used) - "Scenario=My Scenario"
- Option to save the model after the parameters are set (thus, the next time the model is opened in SIMPROCESS, the model parameters set by command line or properties file retain their latest value) - Save=True (the absence of this option is equivalent to Save=False)
- Can set the starting and/or ending date and time of the model. Absence of the time portion indicates midnight. - Start=1/1/2005, End=1/1/2006 08:00:00.

Note: Design and Scenario should not be used on Linux since the SIMPROCESS database is an Access database and is not available for Linux systems. Also, Design and Scenario should not be used on Windows if the appropriate steps have not been taken to set up the database connection (See Chapter 2 of the *SIMPROCESS Getting Started Manual*.)

Setting Options on Command Line

Any parameters to be set must follow the model on the command line. For example

```
SPRunSimulation "C:\Program
Files\SIMPROCESS\models\Demos\Purchasing.spm"
Model.NumProdAPersonnel=6 Model.NumProdBPersonnel=4
"Purchasing=Centralized, Functional" Replications=2 "Design=2 Reps"
"Scenario=Scenario 1" Save=True
```

Parameters that have spaces must be in quotes. The order of the parameters following the model is not important. If Design and Scenario are omitted, then the results are not committed to the database.

Setting Options Using Properties File

The preferred method for setting parameters is to use a properties file. The file can have any name as long as the extension is `.properties`. When using a properties file, the properties file name follows the model on the command line.

```
SPRunSimulation "C:\Program
Files\SIMPROCESS\models\Demos\Purchasing.spm" "C:\Program
Files\SIMPROCESS\models\Demos\Purchasing\Purchasing.properties"
```

This example shows a file named `Purchasing.properties` that is in the directory of the **Purchasing.spm** model. The following is an example of a properties file. Three model parameters are set, one process alternative is set (Purchasing), the number of replications is set, and the Design and Scenario are set. The order is not important. Do not include a Design and Scenario if the results of the run should not be committed to the SIMPROCESS database.

```
Model.NumProdAPersonnel=6
Model.NumProdBPersonnel=4
Model.NumProdCPersonnel=4
Purchasing=Centralized, Functional
Scenario=s1
Design=New Design
Replications=2
```

APPENDIX K

SIMPROCESS and External Java Classes

SIMPROCESS is a Java application. During execution, Java programs use the "classpath" to locate individual classes. In order to use some of the SIMPROCESS special features that use external Java classes, certain aspects of the classpath need to be understood.

There are three specific ways that the classpath can be used to support external Java classes in SIMPROCESS.

- Java Extension Mechanism
- Model-Specific Java Additions
- ext Directory

Please note that there are specific recommendations for when to use one over another, as not all of them are equal.

Java Extension Mechanism

The Java Extension Mechanism provides a way of adding things to the classpath without changes to any files installed with SIMPROCESS. To use it, JAR files containing needed Java packages must be placed where the Java Runtime Environment (JRE) will seek them when it needs to resolve a reference. Since SIMPROCESS installs a JRE for its own use, that location will always be the `jre/lib/ext` directory created by the installer.

Typical Use

The most common use of the Java Extension Mechanism is to support using databases other than Microsoft Access with SIMPROCESS. See "SIMPROCESS and Other Databases" on page 385. In the example cited there, database drivers for MySQL, a popular open source database, are required in order for SIMPROCESS to use it, so one or more JAR files must be placed in this location.

Recommended Use

When third party Java packages are needed by SIMPROCESS, the JAR files containing them can be placed in this location. However, it's recommended that this be done only when specifically necessary and when the model-specific mechanism described in the next section is not appropriate. In particular, database drivers must use this mechanism, as they are handled by SIMPROCESS itself. Therefore, the database drivers will not be sought in model directories.

Warning on Potential File Loss

When adding JAR files to the `jre/lib/ext` directory of an installed copy of SIMPROCESS, it's a good idea to keep copies of the original JAR files. When SIMPROCESS is uninstalled, the uninstaller program will unconditionally remove the entire `jre` directory, thus removing any added JAR files. In addition, every new release installer will install a `jre` directory. It's possible that this can result in the loss of JAR files added here. So any such additions should be double-checked any time a new installer is used.

Model-Specific Java Additions

As of release 4.4, SIMPROCESS provides a new way to use added Java classes. Except in special circumstances (e.g., database drivers), this is the preferred way of adding Java code to SIMPROCESS.

When a model is opened by SIMPROCESS its model directory is created, if not already present. To use user-provided Java classes with the model, a new subdirectory named `classes` must be created in the model directory. When simulating the model, the contents of this subdirectory will be included in the classpath. The `classes` directory can contain:

- Any number of JAR files containing packaged Java classes and related resources to which the model may refer
- Compiled Java classes in directories representing their package structure, along with any related resources to which the classes may refer
- Individual compiled Java class files considered to be in the "default package" (although this is not recommended)

JAR files **and** class files can be used simultaneously with a model.

When to Use classes Subdirectory

The **`ExternalCall`** System Method supports the use of Java classes in this subdirectory (see "Method ExternalCall:," beginning on page 567). Others may be added in the future. As recommended above, the `classes` subdirectory should be used in preference to either of the other described mechanisms (Java Extension Mechanism and ext Directory) except when specifically necessary or impractical not to do so.

Why Use classes Subdirectory

Even if multiple models need to share the same set of classes and/or JAR files, this subdirectory should be used in order to make model sharing easier. Since a model can carry its own background and icon images (see "Importing Graphics Image Files," beginning on page 168) and carry its own external Java classes, the need for instructions on how to place class files and import images is eliminated. Instead, the model file and its like-named directory can be packaged and sent as a single unit. The recipient can then open the model and simulate without having to import background and icon images or place external Java classes in specific locations.

ext Directory

The `ext` directory (see “ext Directory,” beginning on page 476) is included in the SIMPROCESS classpath. This means Java code placed here will be accessible to SIMPROCESS when appropriate. The code should be compiled and its package directory structure copied into the `ext` directory. It is possible to use code without package statements, in what Java refers to as the "default" package, but this is not recommended and not "officially supported" by Sun, though it will work.

In SIMPROCESS releases through 4.3, this directory was the only means of using "loose" Java classes (those not in a JAR file) with SIMPROCESS. Java classes placed here were typically used with the **`ExternalCall`** System Method and other similar features. This directory is still supported for such use, but it is recommended that it only be used when multiple models need to share the same classes (not necessarily simultaneously) and when it's impractical to use the newer model-specific mechanism described in the previous section. Note that only "loose" Java classes may be used in this directory. To use Java classes contained a JAR file, use one of the other means described above.

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